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## ON THE EVOLUTION OF THE FAMILY.

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II.

AND here we come in face of the fact before obliquely glanced at, that Sir Henry Maine's hypothesis takes account of no stages in human progress earlier than the pastoral or agricultural. The groups he describes as severally formed of the patriarch, his wife, descendants, slaves, flocks, and herds, are groups implying that animals of several kinds have been domesticated. But before the domestication of animals was achieved, there passed long stages stretching back through prehistoric times. To understand the patriarchal group, we must inquire how it grew out of the less-organized groups that preceded it.

The answer is not difficult to find if we ask what kind of life the domestication of herbivorous animals entailed. Where pasture is abundant and covers large areas, the keeping of flocks and herds does not necessitate separation into very small clusters: instance the Comanches, who, with their hunting, join the keeping of cattle, which the members of the tribe combine to guard. But where pasture is not abundant, or is distributed in patches, cattle cannot be kept together in great numbers; and their owners consequently have to part. Naturally, the division of the owners will be into such clusters as are already vaguely marked off in the original aggregate: individual men with such women as they have taken possession of, such animals as they have acquired by force or otherwise, and all their other belongings, will wander hither and thither in search of food for their sheep and oxen. As already pointed out, we have, in prepastoral stages, as among the Bushmen, cases where scarcity of wild food necessitates parting into very small groups; and clearly when, instead of game

and vermin to be caught, cattle have to be fed, the distribution of pasturage, here in larger, there in smaller oases, will determine the numbers of animals, and consequently of human beings, which can keep together. In the separation of Abraham and Lot we have a traditional illustration.

Thus recognizing the natural origin of the wandering family group, let us ask what are likely to become its traits. We have seen that the regulating system of a society is evolved in the course of conflicts with environing societies. Between pastoral hordes which have become separate, and in course of time alien, there must arise, as between other groups, antagonisms: caused sometimes by appropriation of strayed cattle, sometimes by encroachments upon grazing areas monopolized. But now mark a difference. In a tribe of archaic type, such ascendency as war from time to time gives to a man who is superior in strength, will, or cunning, commonly fails to become a permanent headship, since his power is regarded with jealousy by men who are in other respects his equals. It is otherwise in the pastoral horde. The tendency which war between groups has to evolve a head in each group, here finds a member prepared for the place. Already there is the father, who at the outset was, by right of the strong hand, leader, owner, master, of wife, children, and all he carried with him. In the preceding stage his actions were to some extent under check by other men of the tribe; now they are not. His sons could early become hunters and carry on their lives independently; now they cannot.

Note a second difference. Separation from other men brings into greater clearness the fact that the children are not only the wife's children, but his children; and further, since among its neighbors his group is naturally distinguished by his name, the children spoken of as members of his group are otherwise spoken of as his children. The establishment of male descent is thus facilitated. Simultaneously there is apt to come acknowledged supremacy of the eldest son: the first to give efficient aid to the father, the first to reach manhood, the first likely to marry and have children, he is usually the one on whom the powers of the father devolve as he declines and dies. Thus the average tendency through successive generations will be for the eldest male to become head of the increasing group, alike as family ruler and political ruler—the patriarch.

At the same time industrial coöperation is fostered. Savages of the lowest types get roots and berries, shell-fish, vermin, small animals, etc., without joint action. Among those who, having reached the advanced hunting stage, capture large animals, a considerable combination is implied, though of an irregular kind. But on rising to the stage in which flocks and herds have to be daily pastured and guarded, and their products daily utilized, combined actions of many kinds are necessitated; and under the patriarchal rule these become

regularized by apportionment of duties. This coördination of functions, and consequent mutual dependence of parts, conduce to consolidation of the group as an organic whole. Gradually it becomes impracticable for any member to carry on his life by himself, deprived not only of the family aid and protection, but of the food and clothing yielded by the domesticated animals. So that the industrial arrangements conspire with the governmental arrangements to produce a well-compacted aggregate, internally coherent and externally marked off definitely from other aggregates.

This process is furthered by disappearance of the less developed. Other things equal, those groups which are most subordinate to their leaders will succeed best in battle. Other things equal, those which, submitting to commands longer, have grown into larger groups, will thus benefit. And other things equal, advantages will be gained by those in which, under dictation of the patriarch, the industrial coöperation has been rendered efficient. So that, by survival of the fittest among pastoral groups struggling for existence with one another, those which obedience to their heads and mutual dependence of parts have made the strongest will be those to spread; and in course of time the patriarchal type will thus become well marked. Not, indeed, that entire disappearance of less-organized groups must result; since regions favorable to the process described facilitate the survival of smaller hordes, pursuing lives more predatory and less pastoral. So that there may simultaneously grow up larger clusters which develop into pastoral tribes, and smaller clusters which subsist mainly by robbing them.

Mark next how, under these circumstances, there arise certain arrangements respecting ownership. The division presupposed by individualization of property cannot be carried far without appliances which savage life does not furnish. Measures of time, measures of quantity, measures of value, are required. When from the primitive appropriation of things found, caught, or made, we pass to the acquisition of things by barter and by service, we see that approximate equality of value between the exchanged things is implied; and in the absence of recognized equivalence, which must be exceptional, there will be great resistance to barter. Among savages, therefore, property extends but little beyond the things a man can procure for himself. Kindred obstacles occur in the pastoral group. How can the value of the labor contributed by each to the common weal be measured? To-day the cowherd can feed his cattle close at hand; to-morrow he must drive them far and get back late. Here the shepherd tends his flock in rich pasture; and in a region next visited the sheep disperse in search of scanty food, and he has great trouble in getting in the strayed ones. No accounts of labor spent by either can be kept, and there are no current rates of wages to give ideas of their respective claims to shares of produce. The work of the daughter or

the bondwoman, who milks and who fetches water, now from a well at hand and now from one farther off, varies from day to day; and its worth, as compared with the worths of other works, cannot be known. So with the preparation of skins, the making of clothing, the setting up of the tents. All these miscellaneous services, differing in arduousness, duration, skill, cannot be paid for in money or produce while there exists neither currency nor market in which the relative values of articles and labors may be established by competition. Doubtless a bargain for services rudely estimated as worth so many cattle or sheep may be entered into. But beyond the fact that this form of payment, admitting of but very rough equivalence, cannot conveniently be carried out with all members of the group, there is the fact that, even supposing it to be carried out, the members of the group cannot separately utilize their respective portions. The sheep have to be herded together; it would never do to send them out in small divisions, each requiring its attendant. The milk which cows yield must be dealt with in the mass—could not without great loss of labor be taken by so many separate milk-maids and treated afterward in separate portions. So is it throughout. The members of the group are naturally led into the system of giving their respective labors and satisfying from the produce their respective wants: they have to live as a corporate body. The patriarch, at once family-head, director of industry, owner of all members of the group and its belongings, regulates the labor of his dependents; and, maintaining them out of the common stock that results, is restrained in his distribution, as in his conduct at large, only by traditional custom and by the prospect of resistance and secession if he disregards too far the average opinion.

The mention of secession introduces a remaining trait of the patriarchal group. Small societies, mostly at enmity with surrounding societies, are anxious to increase the numbers of their men that they may be stronger for war. Hence sometimes female infanticide, that the rearing of males may be facilitated; hence in some places, as parts of Africa, a woman is forgiven any amount of irregularity if she bears many children; hence the fact that among the Hebrews barrenness was so great a reproach. This wish to strengthen itself by adding to its fighting-men leads each group to welcome fugitives from other groups. Everywhere, and in all times, there goes on desertion—sometimes of rebels, sometimes of criminals. Stories of feudal ages, telling of knights and men-at-arms who, being ill-treated or in danger of punishment, escape and take service with other princes or nobles, remind us of what goes on at the present day in various parts of Africa, where the dependents of a chief who treats them too harshly leave him and join some neighboring chief, and of what goes on among such wandering South American tribes as the Coroados, members of which join now one horde and now another, as impulse prompts. And

that with pastoral peoples the like occurs, we have direct evidence: Pallas tells us of the Calmucks and Mongols that men oppressed by a chief desert and go over to other chiefs. Occasionally occurring everywhere, this fleeing from tribe to tribe entails ceremonies of incorporation if the stranger is of fit rank and worth—exchange of names, mingling of portions of blood, etc.—by which he is supposed to be made one in nature with those he has joined. What happens when the group, instead of being of the hunting type, is of the patriarchal type? Adoption into the tribe now becomes adoption into the family. The two being one—the family being otherwise called, as in Hebrew, "the tent"—political incorporation is the same as domestic incorporation. And adoption into the family, thus established as a sequence of primitive adoption into the tribe, long persists in the derived societies when its original meaning is lost.

And now to test this interpretation. Distinct in nature as are sundry races leading pastoral lives, we find that they have evolved this social type when subject to these particular conditions. That it was the type among early Semites does not need saying: they, in fact, having largely served to exemplify its traits. That the Aryans during their nomadic stage displayed it is implied by the account given above of Sir Henry Maine's investigations and inferences. We find it again among the Mongolian peoples of Asia; and again among wholly alien peoples inhabiting South Africa. Of the Hottentots, who, exclusively pastoral, differ from the neighboring Bechuanas and Caffres in not cultivating the soil at all, we learn from Kolben that all estates "descend to the eldest son, or, where a son is wanting, to the next male relation;" and "an eldest son may after his father's death retain his brothers and sisters in a sort of slavery." Let us note, too, that among the neighboring Damaras, who, also exclusively pastoral, are unlike in the respect that kinship in the female line still partially survives, patriarchal organization, whether of the family or the tribe, is but little developed, and the subordination small; and further, that among the Caffres, who, though in large measure pastoral, are partly agricultural, patriarchal rule, private and public, is qualified.

It would doubtless be unsafe to say that under no other conditions than those furnished by pastoral life does there arise this family type. We have no proof that it may not arise along with direct transition from the hunting life to the agricultural life. But it would appear that usually this direct transition is accompanied by a different set of changes. Where, as in Polynesia, pastoral life has been impossible, or where, as in Peru and Mexico, we have no reason to suppose that it ever existed, the political and domestic arrangements, still characterized much or little by the primitive system of descent in the female line, have acquired qualified forms of male descent and its concomitant arrangements; but they appear to have done so under pressure of the influences which habitual militancy maintains. We have an indication of

this in the statement of Gomara respecting the Peruvians that "nephews inherit, and not sons, except in the case of the Incas." Still better are we shown it by sundry African states. Among the coast negroes, whose kinships are ordinarily through females, whose various societies are variously governed and most of them very unstable, male descent has been established in some of the kingdoms. The inland negroes, too, similarly retaining as a rule descent in the female line, alike in the state and in the family, have acquired in their public and private arrangements some traits akin to those derived from the patriarchal system; and the like is the case in Congo. Further, in the powerful kingdom of Dahomey, where the monarchy has become stable and absolute, male succession and primogeniture are completely established, and in the less despotically governed Ashantee partially established.

But whether the patriarchal type of family may or may not arise under other conditions, we may safely say that the pastoral life is most favorable to development of it. From the general laws of evolution it is a corollary that there goes on integration of any group of like units simultaneously exposed to forces that are like in kind, amount, and direction; and obviously the members of a wandering family, kept together by joint interests and jointly in antagonism with other such families, will become more integrated than the members of a family associated with other families in a primitive tribe, all the members of which have certain joint interests, and are jointly in antagonism with external tribes. Just as we have seen that larger social aggregates become coherent by the coöperation of their members in conflict with neighboring like aggregates, so with this smallest social aggregate constituted by the nomadic family. Of the differentiations that simultaneously arise, the same may be said. As the government of a larger society is evolved during its struggles with other such societies, so is the government of this smallest society. And as here the society and the family are one, the development of the regulative structure of the society becomes the development of the regulative family structure. Moreover, analogy suggests that the higher organization given by this discipline to the family group makes it a better component of societies afterward formed than are family groups which have not passed through this discipline. Already we have seen that great nations arise only by aggregation and reaggregation: small communities have first to acquire some consolidation and structure; then they admit of union into compound communities, which, when well integrated, may again be compounded into still larger communities; and so on. It now appears that social evolution is most favored when this process begins with the smallest groups—the families: such groups, made coherent and definite in the way described, and afterward compounded and recompounded, having originated the highest societies.

An instructive analogy between social organisms and individual organisms supports this inference. In a passage from which I have already quoted a clause, Sir Henry Maine, using a metaphor which biology furnishes, says: "All the branches of human society may or may not have been developed from joint families which arose out of an original patriarchal cell; but, wherever the joint family is an institution of an Ayran race, we see it springing from such a cell, and, when it dissolves, we see it dissolving into a number of such cells:" thus implying that, as the cell is the proximate component of the individual organism, so the family is the proximate component of the social organism. But in either case this, though generally true, is not entirely true; and the qualification required is extremely suggestive. Low down in the animal kingdom exist creatures not possessing the definite cell-structure—small portions of living protoplasm without limiting membranes, and even without nuclei. There are also certain types produced by aggregation of such *Protozoa;* and, though it is now alleged that the individual components of one of these compound *Foraminifera* have nuclei, yet they have none of the definiteness of developed cells. In types above these, however, it is otherwise: every cœlenterate, molluscous, annulose, or vertebrate animal begins as a cluster of distinct, nucleated cells. Whence it would seem that the unorganized portion of protoplasm constituting the lowest animal cannot, by union with others such, furnish the basis for a higher animal; and that the simplest aggregates have to become definitely developed before they can form larger aggregates capable of much development. Similarly with societies. The tribes in which the family is vague and unsettled remain politically unorganized. Sundry partially-civilized peoples characterized by some definiteness and coherence of family structure have attained corresponding heights of social structure. And the highest organizations have been reached by nations compounded out of family groups which had previously become highly organized.

And now, limiting our attention to these highest societies, we have to thank Sir Henry Maine for showing us the ways in which many of their ideas, customs, laws, and arrangements, have been derived from those which characterized the patriarchal group.

In all cases, habits of life, when continued for many generations, mould the nature; and the resulting traditional beliefs and usages, with the accompanying sentiments, become difficult to change. Hence, on passing from the wandering pastoral life to the settled agricultural life, the patriarchal type of family, with its established traits, persisted, and gave its stamp to the social structures which gradually arose. As Sir Henry Maine says: "All the larger groups which make up the primitive societies in which the patriarchal family occurs, are seen to be multiplications of it, and to be, in fact, them-

selves more or less formed on its model." The divisions which grow up as the family multiplies become distinct in various degrees. "In the joint undivided family of the Hindoos, the stripes, or stocks, which are only known to European law as branches of inheritors, are actual divisions of the family, and live together in distinct parts of the common dwelling;" and similarly in some parts of Europe. In the words of another writer: "The Bulgarians, like the Russian peasantry, adhere to the old patriarchal method, and fathers and married sons, with their children and children's children, live under the same roof until the grandfather dies. As each son in his turn gets married, a new room is added to the old building, until with the new generation there will often be twenty or thirty people living under the same roof, all paying obedience and respect to the head of the family." From further multiplication results the village community; in which the households, and in part the landed properties, have become distinct. And then, where larger populations arise, and different stocks are locally mingled, there are formed such groups within groups as those constituting, among the Romans, the family, the house, and the tribe: common ancestry being in all cases the bond.

Along with persistence of patriarchal structures under new conditions naturally goes persistence of patriarchal principles. There is supremacy of the eldest male; sometimes continuing, as in Roman law, to the extent of life-and-death power over wife and children. There long survives, too, the general idea that the offenses of the individual are the offenses of the group to which he belongs; and, as a consequence, there survives the practice of holding the group responsible and inflicting punishment upon it. There come the system of agnatic kinship, and the resulting laws of inheritance. And there develops the ancestor-worship in which there join groups of family, house, tribe, etc., that are large in proportion as the ancestor is remote. These results, however, here briefly indicated, do not now concern us; they have to be treated of more as social than as domestic phenomena.

But with one further general truth which Sir Henry Maine brings into view, we are concerned—the disintegration of the family. "The *unit* of an ancient society was the family," he says, and "of a modern society the individual." Now, excluding those archaic types of society in which, as we have seen, the family is undeveloped, this generalization appears to be amply supported by facts; and it is one of profound importance. If, recalling the above suggestions respecting the genesis of the patriarchal family, we ask what must happen when the causes which joined in forming it are removed, and replaced by antagonistic causes, we shall understand why this change has taken place. In the lowest groups, while there continues coöperation in war and the chase among individuals belonging to different stocks, the family remains vague and incoherent, and the individual is the

unit. But when the imperfectly-formed families with their domesticated animals, and the family and the society, are thus separate into distinct groups, made identical—when the coöperations carried on are between individuals domestically related as well as socially related, then the family becomes defined, compact, organized; and its controlling agency gains strength because it is at once parental and political. This organization which the pastoral group gets by being at once family and society, and which is gradually perfected by conflict and survival of the fittest, it carries into settled life. But settled life entails multiplication into numerous such groups adjacent to one another; and in these changed circumstances each of the groups is sheltered from some of the actions which originated its organization and exposed to other actions which tend to disorganize it. Though there still arise quarrels among the multiplying families, yet, as their blood-relationship is now a familiar thought, which persists longer than it would have done had they wandered away from one another generation after generation, the check to antagonism is greater. Further, the worship of a common ancestor, in which they can now more readily join at settled intervals, acts as a restraint on their hatreds, and so holds them together. Again, the family is no longer liable to be separately attacked by enemies; but a number of the adjacent families are simultaneously invaded and simultaneously resist: coöperation among them is induced. Throughout subsequent stages of social growth this coöperation increases; and the families jointly exposed to like external forces tend to integrate. Already we have seen that by a kindred process such communities as tribes, as feudal lordships, as small kingdoms, become consolidated into larger communities; and that along with the consolidation caused by coöperation, primarily for offense and defense, and subsequently for other purposes, there goes a gradual obliteration of the divisions between them, and a substantial fusion. Here we recognize the like process as taking place with these smallest groups. Quite harmonizing with this general interpretation are the special interpretations which Sir Henry Maine gives of the decline of the *patria potestas* among the Romans. He points out how father and son had to perform their civil and military functions on a footing of equality wholly unlike their domestic footing; and how the consequent separate acquisition of authority, power, spoils, etc., by the son, gradually undermined the paternal despotism. Individuals of the family ceasing to work together exclusively in their unlike relations to one another, and coming to work together under like relations to state authority and to enemies, the public coöperation and subordination grew at the expense of the family coöperation and subordination. Not only militant activities, but also industrial activities in the large aggregates eventually formed, conduced to this result. In a recent work on "Bosnia and Herzegovina," Mr. Arthur J. Evans, describing the Slavonic house-

communities, which are dissolving under the stress of industrial competition, says, "The truth is, that the incentives to labor and economy are weakened by the sense of personal interest in their results being subdivided."

And now let us note the marvelous parallel between this change in the structure of the social organism and a change in the structure of the individual organism. We saw that definite nucleated cells are the components which, by aggregation, lay the foundations of the higher organisms; in the same way that the well-developed simple social groups are those out of which, by composition, the higher societies are eventually evolved. Here let me add that as, in the higher individual organisms, the aggregated cells which form the embryo, and for some time retain their separateness, gradually give place to structures in which the cell-form is greatly masked and almost lost, so in the social organism the family groups and compound family groups, which were the original components eventually lose their distinguishableness, and there arise structures formed of mingled individuals belonging to many different stocks.

A question of great interest, which has immediate bearings on policy, remains: "Is there any limit to this disintegration of the family?"

Already in the more advanced nations, that process which dissolved the larger family aggregates, dissipating the tribe and the gens and leaving only the family proper, has long been completed; and already there have taken place partial disintegrations of the family proper. Along with changes which for family responsibility substituted individual responsibility in respect of offenses, have gone changes which, in some degree, have absolved the family from responsibility for its members in other respects. When by poor-laws public provision was made for children whom their parents did not or could not adequately support, society in so far assumed family functions; as also when undertaking, in a measure, the charge of parents not supported by their children. Legislation has of late further relaxed family bonds by relieving parents from the care of their children's minds, and in place of education under parental direction establishing education under state direction; and where the appointed authorities have found it needful partially to clothe neglected children before they could be taught, and even to whip children by police agency for not going to school,[1] they have still further substituted for the responsibility of parents a national reponsibility. This recognition of the individual, even when a child, as the social unit, rather than the family, has indeed now gone so far that by many the paternal duty of the state is assumed as self-evident; and criminals are called "our failures."

Are these disintegrations of the family parts of a normal prog-

[1] *See Times*, February 28, 1877.

ress? Are we on our way to a condition like that reached by sundry communistic aggregates in America and elsewhere? In these, along with community of property, and along with something approaching to community of wives, there goes community in the care of offspring: the family is entirely disintegrated, and individuals are alone the units recognized. We have made sundry steps toward such an organization. Is the taking of those which remain only a matter of time?

To this question a distinct answer is furnished by those biological generalizations with which we set out. In Chapter II. were indicated the facts that, with advance toward the highest animal types, there goes increase of the period during which offspring are cared for by parents; that in the human race parental care, extending throughout infancy and childhood, becomes elaborate as well as prolonged; and that in the highest members of the highest races it continues into early manhood: providing numerous aids to material welfare, taking precautions for moral discipline, and employing complex agencies for intellectual culture. Moreover, we saw that, along with this lengthening and strengthening of the solicitude of parent for child, there grew up a reciprocal solicitude of child for parent. Among even the highest animals, of sub-human types, this aid and protection of parents by offspring is absolutely wanting. In the lower human races it is but feebly marked: aged fathers and mothers being here killed and there left to die of starvation; and it becomes gradually more marked as we advance to the highest civilized races. Are we in the course of further evolution to reverse all this? Have those parental and filial bonds, which have been growing closer and stronger during the latter stages of organic development, suddenly become untrustworthy? and is the social bond to be trusted in place of them? Are the intense feelings which have made the fulfillment of parental duties a source of high pleasure, to be now regarded as valueless? and is the sense of public duty to children at large to be cultivated by each man and woman as a sentiment better and more efficient than the parental instincts and sympathies? Possibly Father Noyes and his disciples, at Oneida Creek, will say Yes to each of these questions; but probably few others will join in the Yes—even of the many who are in consistency bound to join.

So far from expecting disintegration of the family to go further, we have reason to suspect that it has already gone too far. Probably the rhythm of change, conforming to the usual law, has carried us from the one extreme a long way toward the other extreme; and a return-movement is to be looked for. A suggestive parallel may be named. In early stages the only parental and filial kinship formally recognized was that of mother and child; after which, in the slow course of progress, was reached the doctrine of exclusive male kinship—the kinship of child to mother being ignored; after which there came in another long period the establishment of kinship to both.

Similarly, from a state in which family groups were alone recognized, and individuals ignored, we are moving toward an opposite state, in which ignoring of the family and recognition of the individual go to the extreme of making not only the mature individual the social unit, but also the immature individual; from which extreme we may expect a recoil toward that medium state in which has been finally lost the compound family group, while there is a reinstitution, and even further integration, of the family group proper, composed of parents and offspring.

And here we come in sight of a truth on which politicians and philanthropists would do well to ponder. The salvation of every society, as of every species, depends on the maintenance of an absolute opposition between the *régime* of the family and the *régime* of the state.

To survive, every species of creature must fulfill two conflicting requirements. During a certain period each member must receive benefits in proportion to its incapacity. After that period, it must receive benefits in proportion to its capacity. Observe the bird fostering its young, or the mammal rearing its litter, and you see that imperfection and inability are rewarded; and that, as ability increases, the aid given in food and warmth becomes less. Obviously this law, that the least worthy shall receive most, is essential as a law for the immature: the species would disappear in a generation did not parents conform to it. Now mark what is, contrariwise, the law for the mature. Here individuals gain rewards proportionate to their merits. The strong, the swift, the keen-sighted, the sagacious, profit by their respective superiorities—catch prey or escape enemies, as the case may be. The less capable thrive less, and on the average of cases rear fewer offspring. The least capable disappear by failure to get prey, or from inability to escape. And by this process is maintained that average quality of the species which enables it to survive in the struggle for existence with other species. There is thus, during mature life, an absolute reversal of the principle that ruled during immature life.

Already we have seen that a society stands to its citizens in the same relation as a species to its members; and the truth which we have just seen holds of the one holds of the other. The law for the undeveloped is that there shall be most aid where there is least merit. The helpless, useless infant, extremely *exigeant*, must from hour to hour be fed, kept warm, amused, exercised; as during childhood and boyhood the powers of self-preservation increase, the attentions required and given become less perpetual, but still need to be great; and only with approach to maturity, when some value and efficiency have been required, is this policy considerably qualified. But when the young man enters into the battle of life he is dealt with

after a contrary system. The general principle now is, that the benefits which come to him shall be proportioned to his merits. Though parental aid, not abruptly ending, may still sometimes soften the effects of this social law, yet the mitigation of them is but partial; and, apart from parental aid, this social law is but in a small degree traversed by private generosity. Then, when middle life has been reached, and parental aid has ceased, the stress of the struggle becomes greater, and the adjustment of payment to service more rigorous. Clearly with a society, as with a species, survival depends on conformity to both of these antagonist principles. Import into the family the law of the society, and let children from infancy upward have life-sustaining supplies proportioned to their life-sustaining labors, and the society disappears forthwith by death of all its young. Import into the society the law of the family, and let the life-sustaining supplies be inversely proportioned to the life-sustaining labors, and the society decays from the increase of its least worthy members, and disappearance of its most worthy members: it must fail to hold its own in the struggle with other societies, which allow play to the natural law that prosperity shall vary as efficiency.

Hence the necessity of maintaining this cardinal distinction between the ethics of the family and the ethics of the state—hence the fatal result if family disintegration goes so far that family policy and state policy become confused. Unqualified generosity must remain the principle of the family while offspring are passing through their earliest stages; and generosity, more and more qualified by justice, must remain its principle as offspring are approaching maturity. Conversely, the principle of the society must ever be, justice qualified by generosity in private actions, as far as the individual natures of citizens prompt; and unqualified justice in the corporate acts of the society to its members. However fitly in the battle of life among adults, the strict proportioning of rewards to merits may be tempered by private sympathy in favor of the inferior; nothing but evil can result if this strict proportioning is so interfered with by public arrangements that demerit profits at the expense of merit.

And now to sum up the several conclusions, connected though heterogeneous, to which our survey of the family has brought us.

That there are connections between polygyny and the militant type, and between monogamy and the industrial type, we found good evidence. Partly the relation between militancy and polygyny is entailed by the stealing of women in war; and partly it is entailed by the mortality of males and resulting surplus of females where war is constant. In societies advanced enough to have some industrial organization, the militant classes remain polygynous, while the industrial classes become generally monogamous; and an ordinary trait of the despotic ruler, evolved by habitual militancy, is the possession of numerous

wives. Further, we found that even in European history this relation, at first not manifest, is to be traced. Conversely, it was shown that with increase of industrialness and consequent approach to equality of the sexes in numbers, monogamy becomes more general, because extensive polygyny is rendered impracticable. We saw, too, that there is a congruity between that compulsory coöperation which is the organizing principle of the militant type of society, and that compulsory coöperation characterizing the polygynous household; while with the industrial type of society, organized on the principle of voluntary coöperation, there harmonizes that monogamic union which is an essential condition to voluntary domestic coöperation. Lastly, these relationships were clearly shown by the remarkable fact that, in different parts of the world, among different races, there are primitive societies in other respects unadvanced, which, exceptional in being peaceful and industrial, are also exceptional in being monogamic.

Passing to the consideration of the family under its social aspects, we examined certain current theories. These imply that in the beginning there were settled marital relations, which we have seen is not the fact; that there was at first descent in the male line, which the evidence disproves; that in the earliest groups there was definite subordination to a head, which is not a sustainable proposition. Further, the contained assumptions that originally there was an innate sentiment of filial obedience, giving a root for patriarchal authority, and that originally family connection afforded the only reason for political combination, are at variance with accounts given us of the uncivilized. Recognizing the fact that if we are fully to understand the higher forms of the family we must trace them up from those lowest forms accompanying the lowest social state, we saw how, in a small separated group of persons old and young, held together by some kinship, there was, under the circumstances of pastoral life, an establishing of male descent, an increasing of cohesion, of subordination, of coöperation, industrial and defensive; and that acquirement of structure became relatively easy because domestic government and social government became identical: the influences favoring each conspiring instead of conflicting. Hence the genesis of a simple society more developed than all preceding simple societies, and better fitted for the composition of higher societies.

Thus naturally originating under special conditions, the patriarchal group with its adapted ideas, sentiments, customs, arrangements, dividing in successive generations into sub-groups holding together in larger or smaller clusters according as the environment favored, carried its organization with it into the settled state; and the efficient coördination evolved within it favored efficient coördination of the larger societies formed by aggregation. Though, as we are shown by partially-civilized kingdoms existing in Africa, and by

extinct American kingdoms, primitive groups of less evolved structures and characterized by another type of family may form compound societies of considerable size and complexity, yet the patriarchal group with its higher family type is inductively proved to be that out of which the largest and most advanced societies arise.

Into communities produced by multiplication of it, the patriarchal group, carrying its supremacy of the eldest male, its system of inheritance, its laws of property, its joint worship of the common ancestor, its blood-feud, its complete subjection of women and children, long retains its individuality. But with these communities, as with communities otherwise constituted, combined action slowly leads to fusion; the lines of division become gradually less marked; and, at length, as Sir Henry Maine shows, societies which have the family for their unit of composition pass into societies which have the individual for their unit of composition.

This disintegration, first separating compound family groups into simpler ones, eventually affects the simplest: the members of the family proper more and more acquire individual claims and individual responsibilities. And the wave of change, conforming to the general law of rhythm, has among ourselves partially dissolved the relations of domestic life, and substituted for them the relations of social life. Not simply have the individual claims and responsibilities of young adults in each family come to be recognized by the state; but the state has, to a considerable degree, usurped the parental functions in respect of children, and, assuming their claims upon it, exercises coercion over them.

On looking back to the general laws of life, however, and observing the essential contrast between the principle of family life and the principle of social life, we conclude that this degree of family disintegration is in excess, and will hereafter be followed by partial reintegration.

## THE TIDES.

By Professor ELIAS SCHNEIDER.

THERE has always been a difficulty in the minds of teachers, as well as in the minds of learners, to comprehend the theory of the tides as presented in our text-books. This theory fails to give a satisfactory account of the cause of the tides on the side of the earth most remote from the sun and the moon. According to this theory, at that part of the earth's surface which is turned away from the moon or from the sun, a less amount of attraction is felt by her waters than anywhere else on her surface; and the whole earth is therefore, in

effect, drawn away from the waters on the far side of her, and thus, the water being left behind, a tide is produced on this side, as well as on the side at which the force of gravity acts directly. That so great an absurdity could have been accepted so long by our writers of text-books, is truly marvelous. It is, indeed, so contrary to all known facts and laws of physics that, if no other influence were felt by the waters at the far side of the earth than attraction, there would be just the opposite effect produced to that alleged by this absurd hypothesis. This can be demonstrated by actual experiment, and as conclusively as any other fact coming within the reach of experimental philosophy. It has been proved experimentally that all bodies on the surface of the earth at midnight are heavier than at any other hour of the twenty-four; and that when new moon occurs at midnight, this increase of weight or gravity felt by matter on this part of the surface of the earth is still greater. Now, if this theory were correct, attraction would produce just the opposite effect; that is, matter would weigh less at midnight than at other hours of the twenty-four. On the side of the earth facing the sun and moon, the weight of bodies is diminished, as it should be, according to the theory which I propose to establish in this article.

The truth of this fact is very easily accounted for. Suppose the earth were placed in such a position, in space, that she could not feel *any* of the sun's attraction, nor that of any *other* body. Then gravity would be equal on all parts of the earth's surface, on the supposition of its being a perfect sphere and at rest. But now bring her within the attractive influence of the sun. Then all particles of matter on the earth's surface most remote from the sun would feel the force of gravity of both the sun and the earth; and these two forces would act in the same direction and in the same straight line, directed through the centre of the earth to the centre of the sun. On the side facing the sun, these two forces would also act in the same straight line, but in opposite directions. Hence a decrease of weight on one side and an increase thereof on the opposite side of the earth. The same result follows between the earth and moon under a similar supposition. It is therefore not true that the least amount of attraction is felt by the waters of the earth at that part of her surface most remote from the sun or from the moon. It is indeed true that the sun and moon *have* less power of attraction on the particles of matter at this part of the earth's surface than they have on particles of matter facing them. But, as attraction diminishes as the square of the distance increases, this attractive force of these two bodies on any part of the earth's surface is not near so great as that of the earth herself on such part of her surface. Therefore, as these remote particles feel the attraction of sun and moon *plus* the attraction of the earth herself, they are drawn with greater force toward the centre of the earth than any other particles. Consequently, it cannot be true that the whole

earth is drawn away from the waters, and that any tide is produced by the waters being left behind.

How, then, can we account for tides occurring on opposite sides of the earth at the same time? Let us see. In the first place, suppose the earth to occupy some place in space, and to be in a state of perfect rest. Then suppose the sun to come into position, and the earth to start on her journey of 68,000 miles an hour in her orbit around the sun; and suppose, too, that the earth rotates only once on her axis during one revolution around the sun. Then will the same side of her surface face the sun in every part of her orbit. Consequently, there will be a solar tide perpetually at a part of her surface, produced by centrifugal force, and at that part farthest from the sun. Night and solar tide will reign with unceasing steadiness at that one place; but there will be no motion of these piled-up waters. There they will stay, in a steady equilibrium, by the unceasing effect of centrifugal force, in the same manner as can be illustrated by swinging a hollow globe, partially filled with water, around the hand by means of a cord, or by swinging a bucket filled with the same liquid, and having for its bottom a piece of India-rubber, which bottom will bulge out when the bucket is swung around a centre, in the same manner as do the waters of the far side of the earth when she swings or sweeps around the central sun with a velocity of 68,000 miles an hour.

But there are always two solar tides occurring on opposite sides of the earth. The above explanation accounts only for the solar tide on the side of the earth farthest from the sun. How must we account for the fact that there is also one on her side facing the sun and occurring near noon? It is a well-known law of planetary motion that centrifugal and centripetal forces are precisely equal. By virtue of the first the earth seeks to fly from her centre of motion; by virtue of the second she has a tendency to fall into the central luminary; and everything on her surface is operated on in like manner. The particles of her water, moving very easily among one another, are therefore drawn readily away from her solid portions in opposite directions. On the one side the bulging out is caused by centrifugal, on the other by centripetal force. But, as these two forces are nearly equal in all parts of the earth's orbit, the tide-waves on opposite sides of her surface must also be nearly equal. The centrifugal force is produced by the revolution of the earth around the sun; the centripetal force is caused by the force of gravity lodged in the great central orb.

It must not be understood, however, that the earth in her orbital motion feels the effect of these two forces at her surface only. Every *particle* of the matter composing the earth feels both a centrifugal and a centripetal force while this planet moves around the central orb, and these two forces are precisely equal only at the *centre* of the earth. But the matter of her surface most remote from the sun feels

a centrifugal force that is in excess of the centripetal force felt at this same point; and the matter of her surface facing the sun, being nearest to it, feels a centripetal force that is in excess of the centrifugal force felt at this same point. But these two excesses are equal; hence there are equal solar tides at these points, while at the earth's centre there is an exact balancing of the two forces.

Suppose the matter of the earth were all condensed into the volume of a cubic inch, and that this small volume were placed at the earth's present centre; then suppose it received an impulse carrying it forward with a velocity equal to that which moves the centre of the earth, and that it were influenced by the sun, according to the law of gravity. This small volume, though equal in mass to the entire mass of the earth, would then move in the same curve in which the centre of the earth moves, and with the same velocity. But suppose this solid inch of matter were to be placed 4,000 miles farther from the sun, namely, at that point in space where the earth's surface is most remote from the sun. This solid inch, or whole mass of the earth, would then move in a longer curve than it would when at her present centre, as under the first supposition. But completing, nevertheless, in this longer curve, one revolution in the same time in which one revolution is completed in the shorter curve, at the earth's centre, the centrifugal force would be much increased; and, the centripetal force being also diminished in the same ratio, this cubic inch of matter would either abandon the sun's companionship entirely or make a *new* orbit of motion. In like manner are the waters of the earth operated on by centrifugal force at this point of the earth's surface. They have a tendency to fly off in a line tangent to the earth's orbit.

Now, suppose again that this condensed matter of the earth were placed at that point in space where the earth's surface is nearest the sun, namely, 4,000 miles nearer the sun than the centre of the earth is: then the whole mass of the earth's matter would move in a *shorter* curve than when placed at the centre, but, completing one revolution in no shorter period, the centrifugal force would be diminished; and, being also nearer to the sun, the centripetal force would be much increased by the central power of attraction. Therefore, this body of matter would, under this supposition, also leave its orbit, but it would be drawn *toward* the sun, and probably plunge into it. In the one case, the centrifugal being greater than the centripetal force, the body would fly *from* its centre of controlling power; in the other case, the centripetal being equally superior to the centrifugal force, the body would also be drawn out of its orbit, but dragged *to* the centre of controlling power. These suppositions are made to show, by way of illustration, the excessive force of each kind over its opposite, at opposite sides of the earth. And these equally excessive forces, acting in such opposite directions, cause the opposite solar tides. The particles of water, moving easily among one another, are

readily driven in opposite directions by these opposite forces. If the earth were *entirely* solid, then there could be no such bulging out of any of its matter, and therefore no tides.

A few words here in regard to the law of gravitation are in place. Every body of matter attracts every other body of matter, and with a force equal to the *amount* of matter each body contains; and this force diminishes as the square of the distance increases. Two bodies of equal mass approach each other equally; but, if one body contains four times as much matter as another, the smaller approaches the larger with a velocity four times as great as the larger does the smaller. Suppose two such bodies, being separated at a distance of 100,000 miles, attract each other with a certain known force: if this distance be increased to 200,000 miles, the force of attraction between these two bodies will be only one-fourth as great. In like manner, the earth, at the point farthest from the sun, feels a *smaller* degree of attraction than the matter at the centre. And, as the centrifugal force is also *greater* at this point than at the centre, there is here an excess of centrifugal over centripetal force, and sufficient, as can be ascertained by exact mathematical calculation, to produce a solar tide. And at that part of the earth's surface which is nearest the sun, or facing it, there is, according to the same law of gravity, an excess of centripetal over centrifugal force. Hence we have also a solar tide at this part of the surface of the earth.

I give one more illustration. Suppose the earth, at *E* (Fig. 1), is moving in a straight line toward *E'*, and with a velocity of 68,000 miles an hour; and suppose when she reaches *E'* she comes under the

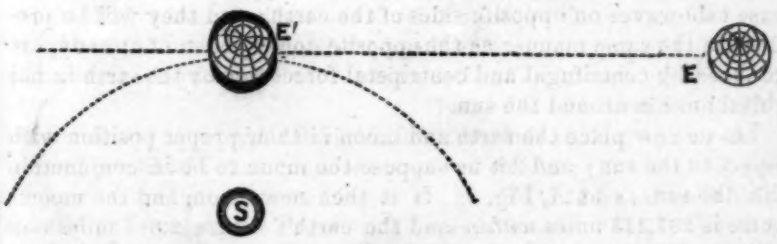


Fig. 1.

attractive influence of the sun. She will then be deflected from her rectilineal course and move in a curvilineal orbit around the sun. That part of her surface turned away from the sun will be 8,000 miles farther from the attractive influence of the central orb than that part of her surface facing the sun. Hence this remote part will have a greater tendency to continue moving on in a straight line than any other part; and this tendency will show itself in the motion of its waters, by producing a tide. The waters will have a tendency to move in a line tangent to the orbit of the earth. The part of the

earth's surface nearest the sun, being acted upon more powerfully by the gravitating influence of this central force than the remote part, will show a less tendency to move on in a line tangent to the earth's orbit. Hence there will be another tide produced by gravity directly.

I have thus far spoken only of the solar tides. It will be necessary also to say something of lunar tides, or what influence the moon has on the phenomena of the tides.

It is a well-known fact that there is a point between the earth and her moon called their centre of gravity. The distance between the centres of these two bodies is about 240,000 miles. A rough calculation brings the centre of gravity of these bodies about 2,687 miles from the centre of the earth, and 237,313 miles from the centre of the moon. This point describes the curve of an ellipse around the sun; and the earth and moon revolve *around* this point, while they both sweep through space in their majestic journey around the sun. It is therefore evident that the earth, in her ceaseless motions, is influenced by three different centrifugal forces. The one is produced by rotation on her axis; the other by her revolution around the sun; and the third by her revolution around the centre of gravity between herself and the moon.

Let us suppose that the earth and moon have no other motion in space than that of revolving around their common centre of gravity, and that the same side of the earth is always facing the moon. The earth will then feel a centrifugal force on her side farthest from the moon, and equal to the centripetal force felt on her side facing the moon. These two equal forces, acting in opposite directions, will cause tide-waves on opposite sides of the earth; and they will be produced in the same manner as the opposite ones, spoken of already, are produced by centrifugal and centripetal forces felt by the earth in her orbital motion around the sun.

Let us now place the earth and moon in their proper position with respect to the sun; and let us suppose the moon to be in conjunction with the sun, as at *A*, Fig. 2. It is then new moon, and the moon's centre is 237,313 miles *within* and the earth's centre 2,687 miles *outside* the elliptic orb described by their centre of gravity. At this point of her path the earth feels, therefore, the greatest amount of centrifugal force on the side of her surface farthest from the sun. This large amount of centrifugal force is produced by axial rotation, by revolution around the sun, and by revolution around the centre of gravity already named. The direction of these three forces is in the same line. The motion of this part of her surface, which is in this line of direction, is therefore the most rapid; consequently, the centrifugal force felt here is also the greatest. *Therefore*, we have one of the highest tides when the moon is in conjunction with the sun; and, since centripetal is always equal to centrifugal force, the side of the

earth facing the sun and moon at this point of her orbit must have an equally high tide at this time. The centripetal force here is produced by the gravity of both sun and moon acting jointly.

Let us now suppose the moon to be in quadrature, as at *B*. Then the two centrifugal forces, the one produced by revolution around the sun, the other by revolution around the centre of gravity of these two

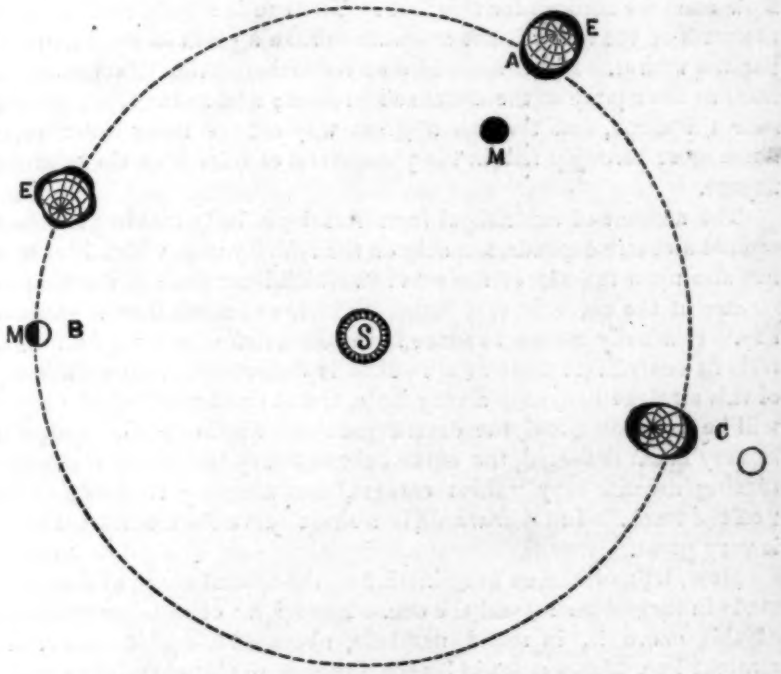


FIG. 2.

bodies, do not act in the same line of direction, but at right angles with each other. The phenomena of solar and lunar tides are then about 90° apart; the solar being the smaller and the lunar the larger. Here the centres of both earth and moon are *in* the path described by their centre of gravity.

In the last place, let us suppose the moon and sun to be in opposition, as at *C*. Then, according to my theory, the earth feels, on her side farthest from the sun, an influence which diminishes the centrifugal force produced by her orbital revolution. For at this point the earth's centre is *within* and the moon's centre is *without* the elliptic path described by their centre of gravity. Here the revolution of the earth around this centre of gravity is contrary to her general motion around the sun. But what is thus lost in centrifugal force on her side turned away from the sun is more than made up by the

gravity exerted directly on her by the moon. And, on the side of the earth facing the sun, she feels a centrifugal force produced by revolution around the centre of gravity of herself and the moon, and also a centripetal force produced by the gravitating influence of the sun. Hence there must be high tide also when sun and moon are in opposition.

It is a known fact that the solar are less than the lunar tides. How must we account for this fact? The sun is a body so large that the mass of the moon is not much more than a grain of sand in comparison with it. But it must also be remembered that gravity diminishes as the square of the distance increases; and as the moon is very near the earth, and the sun a great way off, the lunar influence is much more strongly felt in the phenomena of tides than the solar influence.

The amount of centrifugal force felt by a body moving in space around a centre depends, not only on the velocity with which it moves, but also upon the *size* of the curve in which it moves. If the circumference of the curve is very large, it differs not much from a straight line. If a body moves in space in the direction of a straight line, it feels no centrifugal force at all. If it is deflected from the direction of this straight line, only a very little, the circumference of the curve will be very long, and the centrifugal force will be small. But, if it is very much deflected, the curve becomes very small, and the body, turning around very "short corners," has a strong tendency to fly "off the track." In other words, in a short curve the centrifugal force is very great.

Now, let us make an examination of the orbital curve of the earth made in its motion around the sun. The length of the circumference of this curve is, in round numbers, about 570,000,000 miles. A straight line, 10,000 miles in length, tangent to this curve at one end, is only about .526 of a mile distant from the circumference at its other end. Therefore, the earth, moving in this orbital curve, feels rather a small amount of centrifugal force. But, in her motion around the centre of gravity between herself and the moon, she turns very "short corners," and hence under this influence she experiences a greater amount of centrifugal force than in her motion around the sun. For this reason, *also*, the lunar are greater than the solar tides.

If the earth had only one rotation in one revolution around the sun, there would be, as already stated, one solar tide by virtue of centrifugal force occurring at midnight, and another by virtue of centripetal force occurring at noon. That is, perpetual night and high tide would occur at one side, and perpetual day and high tide at precisely the opposite side of the earth. But now let us suppose the earth rotates on her axis once every twenty-four hours, and from west to east, as she actually does rotate: then there will be motion of the waters; but this motion will be only *apparent* motion, and from east to west.

The *real* motion will be that of the solid portion of the earth that moves from west to east, and underneath these waves, though these waves do also acquire, by means of friction, a *part* of this motion; yet the centrifugal and centripetal forces are so much superior as to master the effect of this friction. This frictional force carries also these tide-waves so far eastward that they occur always several hours east of the meridian; that is, several hours *after* noon, and several hours after midnight.

It is a known fact that the waters of the tides rush up the rivers and small bays on the east coasts of all countries with great violence, but not up those on the west coasts. The reason of this is very evident. The west coasts turn away from the tide-waves; while the east coasts, moving with a velocity of nearly 1,000 miles an hour, in rotation, within all parts of the tropics, dash violently eastward against these waves. For this reason the waters, by resistance or inertia, *appear* to be driven violently westward up the streams and bays, while it is the mouths of these channels ploughing with violence into the tide-waves themselves.

It has been stated in this article that gravity is greater at that part of the earth's surface turned away from sun and moon than anywhere else. It may be asked, "How then can centrifugal force drive out the water above the usual level when its weight is increased?" This force acts in a line tangent to the earth's orbit, which tangent line, being perpendicular to the radius vector at perihelion and aphelion, and at all other points in the earth's orbit very nearly so, may be said to be at right angles with a line extending from this point of tangency through the centre of the earth to the centre of the sun. Therefore, the attractive power of the sun acts on matter, at the part of the earth most remote from it, in the direction of the radius vector; and centrifugal force acts on this same matter in a direction at right angles with the radius vector. Now, as was first demonstrated by Galileo, the motion of a body, produced by one force, is not destroyed by another force acting on this same body at right angles with it. The result of these two combined forces is only a change in the *direction* of motion. But, as has already been shown, centrifugal is always in excess of centripetal force at the place of the earth now under consideration. Hence this tide-wave at this side.

I conclude by saying that the great motions of the waters of the mighty deep are most assuredly the grandest ocular demonstrations of the rotation of the earth upon her axis, and of her revolution around the sun, that can be witnessed by the eyes of man.

# ON GROUND-AIR IN ITS HYGIENIC RELATIONS.[1]

By Dr. MAX VON PETTENKOFER,
PROFESSOR OF HYGIENE IN THE UNIVERSITY OF MUNICH.

IF in the two preceding lectures I have tried to draw your attention to the penetration of the air into our clothing and our dwellings, I shall try in this last lecture to do the same in reference to the air which is in the ground, and to its connection and intercourse with the air above the ground. The air in the ground has been somewhat a stranger to our minds; the terms air and earth, just like air and water, implied to our mind things contrary, and exclusive of each other. The earth seemed to have its limit where the air began. Common-sense seems inclined to believe that there can be no air in that whereon we walk and stand. If we say of the surface of the earth that it is the limit of the earth and the beginning of the atmosphere, we are not correct in reference to the latter. The air begins much below the ground, and we ought to say that where the ground, which is a mixture of earth, water, and air, ends, from there the atmosphere exists alone. It is no wonder that no particular attention was paid to the air in the soil; its presence there does not make any direct impression on any one of our senses; we infer its presence more from other experiences and consequent conclusions. The human mind formerly looked upon the air as something unsubstantial, spiritual, although men saw the effect of hurricanes; no wonder, then, that no one thought of the air hidden in the ground, which cannot even blow the hat from our head.

We again meet here with the fact that, originally, only that calls forth ideas which impresses our senses directly. No one doubts that water penetrates the soil, and moves there according to hydrostatic laws, because we see it run, vanish into the soil, collect and run out again, or we pump it up; but hitherto not many have clearly understood that the whole surface of the earth, as far as it is porous and its pores are not filled with water, contains air, which is also subject to aërostatic laws. And why so? One feels nothing of that air; it is always calm, it has no color, no smell, no taste, in fact we take it for nothing. I have shown you already how great an error we commit when we suppose a calm air to be motionless. This applies just as much to the air in the soil, which, if its motion were even snail-like, would still travel from a good depth to the surface in one day.

Perhaps I shall succeed in giving you a better idea of the change of the air in the ground than of that in walls. To have a correct idea

[1] Abridged and translated by Augustus Hess, M. D., member of the Royal College of Physicians, London.

of that air and its relations, we must know, in the first instance, its quantity in proportion to the different kinds of soil. Let us first take rubble-soil, gravel, or sand, which support the largest and heaviest edifices. Here is a bottle which holds exactly one litre ($1\frac{7}{10}$ pint) up to that mark on its neck. I have filled it slowly with gravel, shaking it all the while, so that the gravel settled completely. The gravel reaches up to the mark. This high cylinder contains just one litre of water, and is graduated into one hundred parts. Now I pour the water into the gravel, till I find it just coming up to its surface, and I see that of the water in the cylinder thirty-five parts have entered the gravel and driven out the air, which before had therefore taken up thirty-five per cent. of the whole mass. This is certainly a great quantity of air, and if we build a house on such a ground its weight rests, no doubt, on the gravel alone, and not on the air; but for all that, this ground, as far as it is dry, consists to the extent of one-third of air. In building on gravel, we build as well on air, just as we build on water when we build on piles driven into a swampy soil and cut off under the water. We know well that a house standing on piles stands with its foot in water, that this water is drawn up by the walls till beyond the water-mark, that the water of the ground has a good deal to do with the house; why should we, then, refuse to acknowledge that the foot of a house built on dry gravel, stands also on the air, and that the air in the ground is in intimate relation with the house?

What I have shown you in regard to gravel, can, in a similar way, be proved in regard to sand, clay, and even more solid stony and rocky soils.

Most kinds of sandstone are nearly as porous as loose sand. The rock of Malta has been proved by Leath Adams to suck up water on an average to one-third of its volume; consequently, when dry it must contain air to the same extent. One would not think that this was the case with the rugged cliffs and shores of that remarkable island, which look as if they were built up from the granite of the Swiss Alps. Most buildings in Malta are built with this Maltese rock, which is much used also throughout Italy. It is not less porous than the Berlin sands; their penetrability for air and water is the same, but the grains of the Maltese rock are connected by some solid medium, while the grains of the sand are loose. In respect to their porosity they stand relatively as frozen and not frozen soil.

Many ships of the English navy have filters made of a certain kind of Maltese rock. I have tested one, and I have found that the filtering basin swallows up forty-seven per cent. of its whole contents, when used for the first time.

A soil whose pores are filled partly by air and partly by water is called damp. It can take up more water till all its pores are filled with it, when all passage of air is stopped, just as we have seen

with regard to the mortar of the house. That degree of humidity of the soil is called *ground-water;* it begins at the lowest limit of the air in the soil.

It is well known that water becomes solid at a temperature below freezing-point. In becoming ice it changes its consistency totally, but its volume not very much, increasing it by about six per cent., one hundred volumes of water becoming one hundred and six of ice. In a frozen soil there must have been a certain quantity of water. This water in freezing has become a kind of cement for the particles of the soil, and gives it a solidity which the liquid water could not

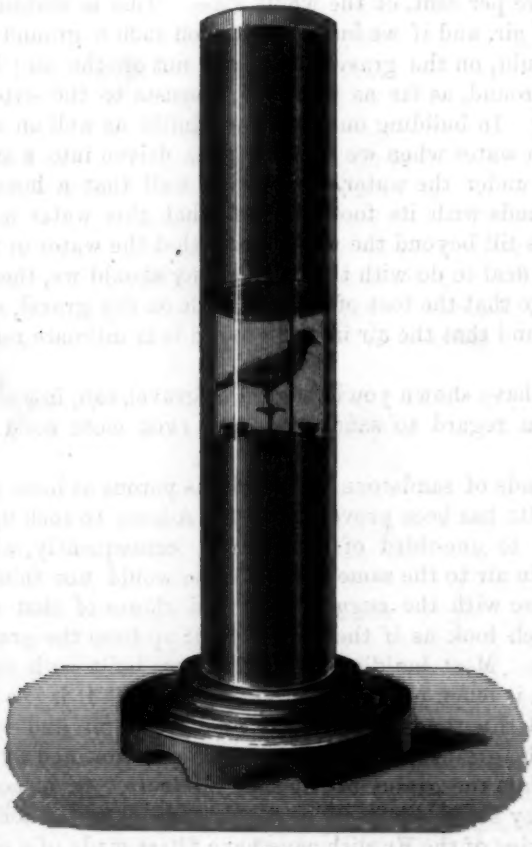

FIG. 1.

impart. Although such frozen soil is as hard to work as stone, we have no right to assume that it is impermeable to air or gases of any kind.

Those pores of the soil which were free from water cannot be narrowed much by the expansion of the neighboring pores through the

freezing of their water. It would be just as incorrect to deny the permeability to air of the frozen soil as that of the Maltese rock. Still, the most erroneous views have been formed on this subject, even by men distinguished in other branches of science.

Having given you an idea of the quantity of air in a porous soil, I have to give you a correct idea of the mobility of this air and of its change, and I shall try to do this in a roundabout way, as I cannot do it by direct impression on your senses.

There are things of whose existence we become only aware when they are absent. Probably the fish is as little aware of the water he lives in as we of the air, till he finds himself on the dry land. The creatures living in the air know nothing of its oxygen, but, when we place them in an atmosphere which has none or too little of it, or too much carbonic acid, they will feel and behave like the fish out of water. There is a difference in the want of oxygen between different animals; birds want a good deal proportionately. A canary-bird takes about one and a third cubic inch of oxygen from the air in one hour. In one litre of air there are about thirteen cubic inches of oxygen, which the bird would have consumed in ten hours. But he would be dead long before, as he could not live in an air deprived of one-half of its oxygen. The bird in this glass cylinder has been shut up between gravel for the last ten hours, and you see he is quite well. The cylinder is shut at its lower end by a wire netting, on which a stratum of gravel rests. The bird stands on the gravel, and above him there is another wire netting, which supports a stratum of gravel. The free space for the bird contains about one litre of air.

This bird is shut up in the same way as workmen sometimes are, digging at a well or at some kind of shaft. If accident does not kill them at once, they seldom die from want of air, even if it takes some days to dig them out, although man's consumption of oxygen is about a thousand times as great as that of the canary-bird. Some years ago, in Saxony, two men who were shut up in the shaft of a well for ten days kept alive, and were not much the worse for it when they came out again. I may mention here that the celebrated Fraunhofer, when still apprenticed to a glazier at Munich, was buried for several days under the ruins of his master's house, which had fallen in.

I expect Fraunhofer's luck will be shared by this bird, whom I intend removing to-morrow to his old cage.

You cannot longer have any doubt about the motion of the air through gravel: but I want to convince your senses; I want you to *see* the motion of the air, and to *see* that motion taking place through a much thicker stratum of gravel than the strata shutting in the bird.

You see this high glass cylinder (Fig. 2), with a smaller glass tube inside, open at both ends. The cylinder is filled with gravel, and the glass tube connected with a manometer by some India-rubber tubing.

As soon as I blow gently on the upper surface of the gravel, you see the liquid in the manometer moving. The motion of the air which I produce acts in the first instance on the surface of the gravel, propagates itself through the same to the bottom of the cylinder, enters

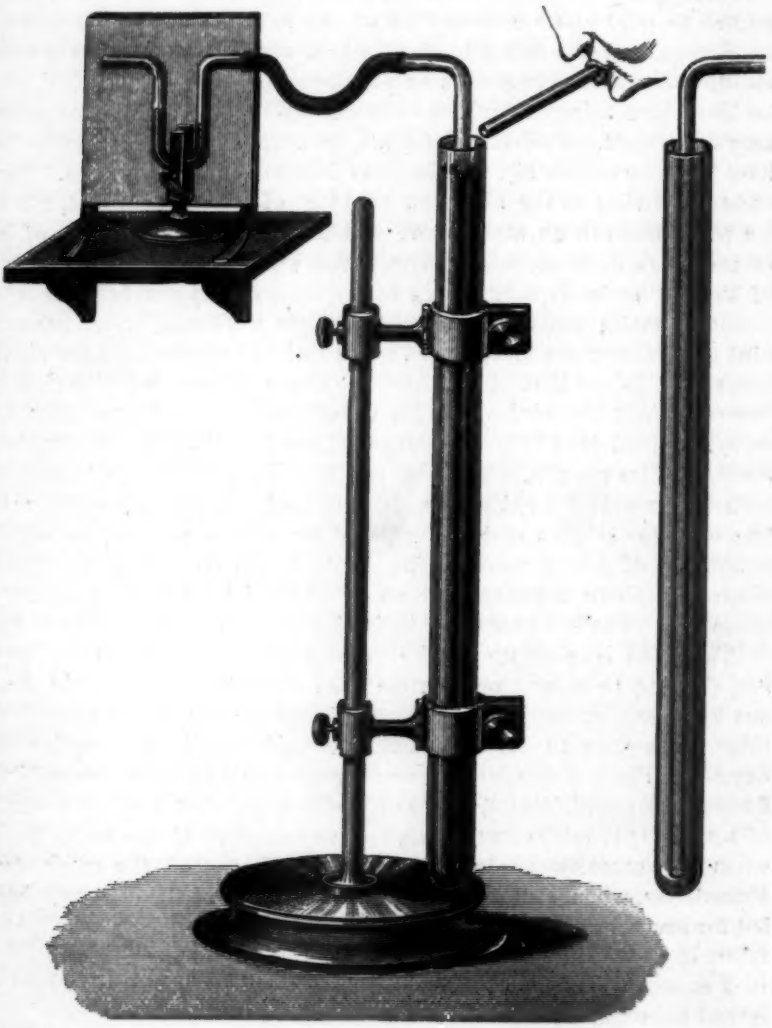

FIG. 2.

the lower end of the tube, rises through it and through the tubing into the manometer, where it presses on the column of liquid, and sets it in motion.

Why does the liquid move in the manometer? Because the air, after the migration just described, presses with greater weight on the

surface of the column it arrives at than the outer air on the surface of the other column. If there were no liquid in the manometer, the moved air would finally flow out of the manometer, and, as you see, now that I have emptied the manometer, nearly blow out this candle.

In this way I believe that I have convinced your senses that the air can move through porous soils.

If the air in the ground can be set in motion by the pressure of air or wind against its surface, there can be no doubt that the same can be effected by differences of temperature, and by diffusion, and generally by all causes which can produce movement of gases. As long as the air in the ground is of a different temperature or composition from the free atmosphere, there must be exchange and motion. I will only, in order to leave no doubt on your mind, direct your attention to several well-known facts, which can only be explained by the change of the ground-air.

All Christian nations bury their dead in the earth, to give back to dust what came from dust. There are burial-grounds in which a corpse decays completely in six to seven years, and others in which it takes twenty-five to thirty years. The regulations about a second occupation of a ground depend on this difference, and therefore towns with an equal population may be obliged to have burial-grounds of very different sizes. There are other circumstances of some influence on the process of decay, but the principal one is the amount of, and the facility for, the change of the air in the soil. Rubble and sandy soils do the work much quicker than marl and clay soils. Striking experiences in this respect have been made on the French battle-fields, chiefly near Sedan, where a Belgian chemist, Louis Creteur, had to disinfect the large dead-pits. The bodies were buried in chalk, quarry, rubble, sand, argillite, slate, marl, or clay soils, and the sad work lasted from the beginning of March to the end of June. In rubble the decay had taken place fully, but in clay the bodies were surprisingly well kept, even after a very long time, and even the features could be identified.

As the processes of putrefaction and decay are intimately connected with the activity of certain lower organisms, which prey upon the dead, it is sufficiently clear that these organisms must thrive differently in different kinds of soil. A lively change of air and water in the ground appears to be of great influence in this respect; the more air in the ground the richer the underground life.

Remarkable testimony as to the permeability of the ground, and of the foundations of our houses, has been given by gas emanations into houses which had no gas laid on. I know cases where persons were poisoned and killed by gas which had to travel for twenty feet under the street, and then through the foundations, cellar-vaults, and flooring of the ground-floor rooms. As these kinds of accidents happened only in winter, they have been brought forward as a proof that

the frozen soil did not allow the gas to escape straight upward, but drove it into the house. I have told you already why I take the frozen soil to be not more air-tight than when not frozen. In such cases the penetration of gas into the houses is facilitated by the current in the ground-air caused by the house. The house, being warmer inside than the external air, acts like a heated chimney on its surroundings, and chiefly on the ground upon which it stands, and the air therein, which we will call the ground-air. The warm air in the chimney is pressed into and up the chimney by the cold air surrounding the same. The chimney cannot act without heat, and the heat is only the means of disturbing the equilibrium of the columns of air inside and outside the chimney. The warm air inside is lighter than the cold air outside; and this being so, the former must float upward through the chimney, just like oil in water. It continues to do so as long as fresh cold air comes into its neighborhood from outside. As soon as we interrupt this arrival, the draught into the chimney is at an end. Any other way of looking at the action of chimneys leads to erroneous views, which have many times stopped the progress of the art of heating and ventilating.

Thus our heated houses ventilate themselves not only through the walls but also through the ground on which the house stands. If there is any gas or other smelling substance in the surrounding ground-air, they will enter the current of this ventilation. I have witnessed a case in Munich, where not the least smell of gas could be detected in the street, but a great quantity of gas found its way into the ground-floor room of a house where no gas was laid on. In another case the gas always penetrated into the best heated room and produced an illness of its inmates, which was taken for typhoid fever.

The movement of gas through the ground into the house may give us warning that the ground-air is in continual intercourse with our houses, and may become the introducer of many kinds of lodgers. These lodgers may either be found out, or cause injury at once, like gas; or they may, without betraying their presence in any way, become enemies, or associate themselves with other injurious elements, and increase their activity. The evil resulting therefrom continues till the store of these creatures of the ground-air is consumed. Our senses may remain unaware of noxious things, which we take in, in one shape or another, through air, water, or food.

We took rather a short-sighted view all the while, when we believed that the nuisances of our neighbors could only poison the water in our pumps; they can also poison the ground-air for us, and I see more danger in this, as air is more universally present, and more movable, than water. I should feel quite satisfied if, by my lectures, you were convinced of this important fact, if of none other.

England has given proof how the public health can be improved,

by keeping the soil clean through good drainage, abolition of cesspools, and abundant water-supply. It would carry me too far if I were to analyze now to which of these measures the lion's part belongs; I should have to enter upon many controversies, which I have no time to fight out in this place; but this is my conviction, which I want to impress upon you, that cleanliness of the soil and diminution of organic processes in the ground of dwelling-houses are most essential.

Many have considered these processes, and their effects on the ground-air, to be a mere hypothesis. This view lies now behind us, and facts have been found proving their reality. Stimulated by the investigations of Huxley and Haeckel, further researches have followed, and shown that not only at the greatest depth of the sea, but also in every porous soil, there are everywhere those beginnings of organic life, belonging neither to the animal nor vegetable kingdom, mucous formations, which are called Moneras and Protistes. When I wrote my part of the report on the cholera in Bavaria, in 1854, I pointed out already that the air, not less than the water in the soil, ought to be drawn into the circle of experimental investigations. Neither others nor myself acted at once upon my suggestion, and it is only during the last eighteen months that I have examined the ground-air in the rubble-soil of Munich, regularly twice a week, for its varying amount of carbonic acid. The results are surprising, and for the future I shall have to trouble others and myself, not only with ground-water, but also with ground-air.

The place where the examination of the ground-air of Munich is being carried on is rubble, without any vegetation, and the carbonic acid increases with the distance from the surface. Agricultural chemistry has been aware, for a long time, that a clod of arable earth which is rich in humus is a source of carbonic acid, but no one expected that, at times, so much carbonic acid should be met with in sterile lime-rubble. A few feet under the surface there is already as much carbonic acid as in the worst ventilated human dwelling-places.

I have found that the quantity of carbonic acid is smaller at fifty-eight inches than at one hundred and fifty-six inches throughout the year, the months of June and July excepted, when an inverse proportion arises. But then there begins also, in the lower stratum, a considerable increase, so that the upper stratum soon finds itself behind again. This large quantity of carbonic acid in the ground-air of Munich has been far surpassed in Dresden. Examinations have taken place in that town under the authority of the Central Board of Public Health. Prof. Fleck's diary proves that, at least at that spot where his examinations took place, the quantity of carbonic acid was in winter already nearly twice as great as in Munich in the month of August. I might become jealous of Dresden, but we must often,

in life, put up with being left behind, although we had the first start, and I have no choice left but to resign myself.

The presence of carbonic acid in the soil and its periodical motion are for the present a bare fact. Other places, with different soils, must be examined under varying circumstances, and for longer periods, before an explanation can be attempted.

The first question which naturally meets us is that about the origin of this gas. It cannot spring from the humus of the surface, because at Munich and Dresden its quantity is smallest in the immediate neighborhood of the surface, where the humus lies, and increases in proportion to the distance thence. As the amount of carbonic acid in the ground-air generally increases the nearer this is to the ground-water, we should be at first sight inclined to assume that it evaporates from it. Is it not a fact that the ground-water which feeds wells and sources contains this gas? And is it not well known that many a well's shaft contains so much carbonic acid as to extinguish a burning candle at the distance of a few feet only from its opening? This assumption, however, is not justified for several reasons, according to the researches and experiments made at Munich: 1. There are two months in the year when the amount contained in the upper stratum, which is at the greatest distance from the ground-water, is larger than in the lower. 2. I have examined simultaneously, at given places, the amount of the gas both in the ground-water and in the ground-air, and have investigated whether, according to the laws of diffusion and absorption, either had a surplus of the gas, and was accordingly in a condition to receive or yield some of it. In every case the amount of carbonic acid in the ground-air was larger by fifty per cent. than in the ground-water, so it is clear that it is the water which receives its carbonic acid from the air, and not *vice versa*.

Hereby the question about the origin of the gas is certainly not yet answered, and would have been left equally unsettled if we had to ask, Whence comes all the carbonic acid which is found in the ground-water? All this water is precipitated from the atmosphere, from rain or snow. In entering the soil as meteoric water its amount of carbonic acid is exceedingly small. By help of Bunsen's analytical tables it is easy to calculate, from the quantity of carbonic acid in the atmosphere, and the absorbing power of water for this gas, that one pint of rain-water at the average temperature and barometrical pressure can only contain a very small fraction of a grain of carbonic acid, and this has been proved further by analytical experience. But the analysis of the pump-water in Munich which was poorest in carbonic acid showed that it contained on an average $1\frac{1}{2}$ to $1\frac{3}{10}$ grain of the free gas. The ground-water at the places of examination stands about sixteen feet from the surface. It is therefore evident that the meteoric water, which is the sole source of the ground-water, must more than centuple

its original amount of carbonic acid before it reaches the wells. Thus much is certain, that the source of the carbonic acid must be sought for in the soil, and for this reason the more natural supposition is, that the soil yields the gas and gives it to the water and to the air simultaneously, but naturally with greater facility and in greater quantity to the air than to the water. The sources of the carbonic acid in the soil have now to undergo a stricter investigation; the probability is, they owe their origin to organic processes in the soil.

Allow me, now, a few more concluding and valedictory words.

In the introduction to my lectures I thought it incumbent upon me to give you my views about popular lectures in general. Those views necessarily excluded the possibility of disposing, in a few hours, of any one subject of hygiene in such a manner as to impart to my audience a thorough theoretical and practical knowledge. My hesitation in selection lasted some time. I might have collected and described the last works and tendencies in the field of hygiene, pointing out what had practically succeeded, and what ought to be aimed at further—and there is a series of interesting points and facts, forming a most grateful subject for lecturing; or I might have attempted to give you a survey, a kind of bird's-eye view of the whole domain of hygienic science. There is a charm, in the contemplation of a grand and beautiful distant landscape, in marking, first, the more interesting points; then to let the eye wander round them till it comes to the next striking point, and to enjoy to the utmost the sight of the rich view.

I might, perhaps, have succeeded in satisfying your expectations up to a certain point, but I thought it preferable to direct and to concentrate your attention mainly upon one single object which is known to every one, and which seems to be so thoroughly examined that many believe that there is very little to say about it—the air, in its hygienic relations to man's clothing, to his dwelling-place, and to the soil on which he builds.

It is such a natural error to imagine that we cannot but understand everything with which we are in continual intercourse; but, if we take the trouble of looking a little more closely into everything of which we make daily use, we shall soon make the humiliating discovery that we are acting preëminently according to instinct and tradition, and much less by personal understanding. Each period has its own task, to contribute and to create something by which civilization gains materially or ideally. But if at any one period we examine into the daily life of its generation, we shall find a great deal more that is inherited than self-acquired. This fact ought to make us modest and zealous, but also just and thankful toward our forefathers, who did not possess or know many things which we possess and know now.

As animals make use of Nature and her laws in a multifarious and surprisingly appropriate manner, so does man also. Each carrier on the road makes use of the laws of motion and friction, and of those

of living force and its preservation, but he does so for the most part quite mechanically, so that he appears to think no more about it than the beaver when he builds his hut. Man also does most things long before he understands them, and this is part of his nature. If he could make use of things only after having thoroughly investigated them, his life would be a poor one, and barely possible. If we had to study the functions of our clothing and its material before we could put it on, we should be frozen to death long before, and no carrier would have attempted to horse his cart before the time of Galileo and Newton.

Here I find myself drawing a dangerous parallel. You may ask me at once whether I believe a carrier will be a better carrier for understanding the laws of motion, and whether our clothing and our dwellings will one day be superior to what they are now, because we shall then have learned to understand their functions better. I leave the answer to the future with the utmost confidence. The experience of the past sets me completely at ease. At all times and everywhere it has been the case that each progress in the recognition of laws, that each new fact established, and each new method applied by science, each new way on which science has directed us, has finally had its practical and useful consequences. Excuse me if I continue to dwell on this favorite subject of mine.

What men call useful is quite a relative term; they call a thing so as soon as they find out what use they can make of it. Of course, a thing must exist before we recognize it, and we must become aware of certain of its properties and relations before we can make use of them for any practical purpose. Certainly the recognition of the laws of motion by Galileo, Kepler, Newton, Laplace, and others, has not brought about a revolution, or made a sensation among the carriers, but from these recognized laws sprang and were evolved new ideas, purified from the gross primitive slag, and they led on to the railway, etc. Other examples demonstrate still more clearly the connection between theory and practice.

Electric telegraphy, which is not only practical and useful, but already indispensable to us, had its first origin in the observations of the anatomist Galvani, who saw the legs of frogs quiver when they came in contact with different metals. Imagine to yourself great practical men of the time, whether statesmen, or divines, or soldiers, or physicians, witnessing Galvani's experiments going on year after year; certainly every one of them would have thought that the man could apply himself to something more useful. But from that form of electricity which Galvani detected there sprung the researches and works of Volta, Sömmering, Steinheil, Morse, and Wheatstone, to whom we owe the whole of our telegraphic system. Place together in your mind the quivering leg of the frog and the transatlantic cable.

After the discovery of Columbus the Spaniards found in the sand

of a river grains of a white metal, which was not affected by fire, and appeared, therefore, to be a noble metal. Quantities were brought to Europe, and the new metal received the modest name of *platina* (low silver), this being a diminutive of *la plata* (silver). The masters of the Mint, the gold and silver smiths, had soon formed their ideas about the new metal; it could neither be melted by itself, nor hammered, nor rolled, nor dissolved in *aqua-fortis*. It was only soluble in *aqua-regia* and other melted metals, but the combinations were all brittle and discolored; in short, it came to be considered a perfectly useless metal, practically worth less than lead and iron. Its importation was prohibited by the Spanish Government, because there was danger of its high specific gravity leading to its use for the adulteration of gold. What platina there was in the country already was thrown into the sea by order. But Science, who makes no difference between the useful and useless, and considers everything useful which increases our insight into the things that are, has quietly held intercourse with the outcast metal; she learned how to tame the shrew, and since Wollaston platina is considered to be one of the most pliable and useful of metals; just what were originally considered its vices have enhanced its value so much in the course of time that weight for weight the "low silver" is paid seven times as much for as the "high silver."

Modern times have not ceased furnishing numerous examples of the same kind, showing that it is not the business of science to ask for the immediate profit, for the immediate practical use. They do not fail to come forth in time.

Science may point to the words of the Bible: "But seek ye first the kingdom of God and his righteousness, and all these things shall be added unto you." All sciences are provinces of God's infinite kingdom, and in them, as everywhere in God's kingdom, Justice is dealt by Truth alone. This was my standpoint, which helped me over the doubts I might have had concerning the *utility* of these lectures. It seemed to me that the principal thing was not to present to you a series of practical applications and contrivances, but a series of truths, which carry in themselves their use and applicability, and impose their authority in proportion as they are talked over more frequently, understood more clearly, and felt more vividly.

But I wanted to tell you the whole truth about the things which formed the subject of my lectures, and it became my duty to draw your attention not only to what is positively known, what is complete, what requires no further investigation, but also to point out to you much greater fields of hygiene, where scarcely a seed has been sown. Otherwise I should probably have jeopardized the only and immediate practical use which my lectures can have here, and which I believe to be this: that the conviction may spread and take root everywhere, that hygiene has been neglected until now, prac-

tically as well as theoretically, and that this neglect is a dark spot on our civilization, which has to be removed by this generation This conviction begins just now to lay hold of ever-widening circles of society, and a certain sympathy is stirring for the interests of public health, much more than formerly. The weather seems suitable for ploughing fields which have remained untouched, and for sowing good seeds where a rank vegetation has been growing.

When a current, a general motion of men's minds, sets in toward some definite goal, then it becomes the duty of all those who are their leaders to choose the proper routes with earnestness and conscientiousness. If a good intention in behalf of some object is wrongly directed, it soon turns against the object itself; all those who allowed themselves to become interested therein turn away discouraged as soon as they believe that their good intention has been wasted to no purpose, and hence those unlimited reactions and rebounds in public opinion. I believe that I am under a moral obligation to speak out in this place. I do it here, perhaps, more confidently than anywhere else, because I feel that here I am understood. I feel it, through the very fact that I have been requested to give my lectures before this audience. The request came to me from the Committee of the Albert Society, from its exalted Lady President. The existence of the Albert Society, its organization, its functions, its efficiency, and its authority, are ample proofs that the value of hygiene is understood here.

In this place I must also acknowledge that the Saxon Government was the first in Germany to establish a Central Board of Public Health; it has also included the teaching of hygiene in the teaching of military medical science. Such arrangements appear to me to be types of the two directions which must now be taken and followed out: on the one hand, investigation, observation, and experiment; on the other, systematic personal teaching. These are the only two ways which lead to the goal.

You have been enabled to see, from that single subject I have treated, how much remains to be done and created; everything is still insufficient and incomplete, and has to be developed and determined. Think of the great chapters—air, clothing, dwelling, ventilation, heating, lighting, building-places, and soil—their relation to air and water, and their influence on the course of disease; epidemics, and protection against them; drinking-water, and its distribution among the population; alimentations and articles of food; the maintaining of different classes of men under different circumstances; dietaries; public baths; gymnastics; collection and removal of excrementitious matters and refuse from households and trades; drainage; disinfection; inspection of dead bodies and their interment; unhealthy trades and manufactories, schools, barracks, asylums, hospitals and nursing, prisons, health statistics, etc.

There is not one among these departments of hygiene in which nothing is left to be done; in most of them the work has scarcely begun. There has always been a desire for and an aiming at health; but ideas about it have changed completely. The former supports of hygiene have crumbled away in the powerful analytical solvents of modern physiology; very little has remained; everywhere new foundations are necessary. This requires workmen; the season appears favorable—do not let it pass unemployed.

It is not sufficient to build up correctly a series of hygienic truths, which might be the work of a few; these truths must be brought to bear upon life, and this requires instruments. Three professions are in real life the natural trustees and representatives of the hygienic interests of the community—physicians, architects, and engineers, and also the public administration. There must be harmonious action between them; good intentions are not sufficient; there must be knowledge and power. Only good musicians can make good music, and they must be well taught and practised. The institutions at which the members of these professions have received their education have all the while generally ignored hygiene as an independent branch of study. A vague supposition left it to the individuals concerned to take the trouble of gathering for themselves whatever was known or would be made public about matters of hygiene. Lectures on forensic medicine were supposed to be sufficient, but they have to consider facts and evidence only with regard to penal laws, which themselves result from the old and highly-cultivated science of jurisprudence. Hygienic laws must spring from hygienic science, and there was none.

Many of the existing hygienic laws and regulations cannot be kept up if examined by the light of hygienic science as it is now. It is no good going on issuing public regulations, demonstrative of good intentions, for the public health; the right thing is to create a firm basis for practical purposes and public measures. Hygiene must become an independent branch of study, to be taught by special teachers at universities, medical and polytechnic schools, not without the help of proper laboratories. Systematic instruction must be offered to students and practitioners of medicine, to members of the civil or municipal service, to architects and engineers. Books and reading can as little occupy the place of personal teaching and experimental investigation as a medical book in the library that of the physician, or a hand-book that of the public chair. The self-taught hygienist has frequently to look out for principles on which to act, while he is called upon to act at once, and routine alone is a dangerous and unreliable assistant. There are exceptions—brilliant ones even—but exceptions prove the rule.

The increasing interest taken by the intelligent and well-meaning members of society in matters of public health, which have also an

intimate connection with the public purse, cannot fail to assist the whole movement which is taking place in favor of hygienic science and its independent and well-endowed instruction.

The whole movement is still going on, but not without resistance here and there. This resistance shields itself, sometimes, behind the pretext that there are at present not enough well-qualified teachers. Certainly the beginning has its difficulties, but everything must have its beginnings. This was the case with the first periodical in Germany for public hygiene, founded by Dr. Varrentrapp, which has achieved an entire success, in spite of all misgivings and discouraging vaticinations before it was started. Worthy representatives of the neglected science will be found for teaching it, as soon as a serious demand manifests itself. A certain species of medical men will be quite made for it, after some preparation. Hygiene is, after all, nothing but applied physiology, with particular reference to the physical well-being of mankind. According to my experience, men of science and physicians, who are specially grounded in the practical and theoretical study of physiology, chemistry, and natural philosophy, are those who can most easily fit themselves for the special work of hygienic science. It is true, physiology includes the most essential points of hygiene, and physiology is an application of natural philosophy, chemistry, and anatomy. But as the votaries of the latter sciences have never done the work of pure physiologists, so these would never have done, and never will do, the work of pure hygienists. England has preceded other countries in the creation of professorships for hygiene. I confidently believe that the proper men, in sufficient number, will also be met with in Germany in a short time.

Should my lectures in Dresden have had the effect, in some degree, of turning your hearts and minds toward the most pressing tasks of hygiene, so that every one of you may do his best for them in his own sphere, then I am sure I have done something practically useful, and have not spoken in vain.

## A BRIEF HISTORICAL SKETCH OF THE DISCOVERY OF THE CIRCULATION OF THE BLOOD.

By GEORGE JACKSON FISHER, M. D.

AMONG the great discoveries which the genius and patient research of man have developed, none lay us under more grateful obligations, in view of its practical value and admirable simplicity, than that of the circulation of the blood. Historians record the rise, progress, and decline of nations, the discovery of new countries, and

the exploits of conquering heroes, and yet pass almost unnoticed the achievements of men of science. Few persons are at all acquainted with the history of when and how, through a series of successive revelations, this truly wonderful function came to be thoroughly understood. It is a long and delightful story if followed through all its details, which I shall, however, endeavor to cut short in relating it to persons outside of the medical profession. We are obliged to glance back through several centuries and make the acquaintance of nearly a score of anatomical celebrities, who have each contributed some observation or discovery leading to the final comprehension and complete interpretation of God's beautiful but simple method of circulating the vital fluid and keeping it ever replenished and pure.

The pathway to the climax of this discovery was not only long but rugged, hedged in by deeply-rooted errors, and obscured by rank prejudices ancient and wide-spread. The errors must be destroyed, the clouds dispelled, parts carefully observed; the explorers must work slowly and cautiously, and what is discovered must be explained. Thus it came to pass that anatomists discovered one thing after another, and little by little the light of truth dawned upon their minds, wherewith they saw and gave the world sensible ideas of the uses of parts, when eventually "the immortal Harvey," the crowning light, the clear-headed philosopher, the Newton of physiology, drew the simple chart of the double circulation. This event took place two hundred and fifty-seven years ago, for it was in 1619 that Harvey completed the discovery. He made no haste to tell the world what he had done, except what the individuals of his classes learned from his lectures, for he taught his discoveries ten full years before he published his modest but wonderful little book "Concerning the Motion of the Heart and Blood in Living Creatures," printed in Latin at Frankfort-on-the-Main, in a thin quarto of only seventy-two pages, in the year of grace 1628.

I propose to give a brief account of the antecedent errors and discoveries to the time of Harvey—that of Erasistratus, who taught that the arteries were air-vessels; of Galen, who demonstrated that they are blood-vessels as well as the veins; of Vesalius, who convinced the world that Galen erred in declaring that holes existed in the partition between the two sides of the heart; of Servetus, Columbus, and Cæsalpinus, who, quite independently of each other, discovered the circulation through the lungs; of Fabricius, who discovered the valves in the veins; of Harvey, who first comprehended the entire circulation; of Asellius, who discovered the lacteals; Pecquet, the receptacle of the chyle; Rudbeck, the lymphatics of the liver; and, lastly, of Thomas Bartholin, who discovered the lymphatics of the whole body.

Erasistratus (300–260 B. C.), a Greek physician and anatomist, of Iulis (the modern Zea), in the island of Ceos, was the grandson of the

illustrious Aristotle, being the son of one of his daughters. It is said that he was so fond of anatomical pursuits that he retired from his practice in Alexandria, where he had settled, the better to gratify his taste. He wrote several treatises which are lost, and all we possess of his writings are a few fragments preserved in the works of Galen. From these we learn that he gave names to the auricles of the heart. He declared that the veins only were blood-vessels, and that the arteries, as their name implies, were air-vessels. The sole purpose of breathing was to fill the arteries with air; the air distended the arteries and made them beat, the air caused the pulse. The air, once in the left ventricle of the heart, became the vital spirits. The office of the veins was to convey blood to the extremities. When the veins carried blood only and the arteries were filled with vital spirits, then perfect health was maintained; but the entrance of blood into the arteries, which he admitted to sometimes occur, was abnormal and the source of disease—fevers when it entered some noble part or into a great artery, and inflammations when it was found in the less noble parts or in the extremities of the arteries. Thus it is seen that a stupendous error was established on a mighty authority. This error was destroyed by Galen four hundred years subsequently to the time of Erasistratus.

Claudius Galen (A. D. 131), next to Hippocrates the most celebrated physician the world ever produced, was born at Pergamus, in Asia Minor, about the year of our Lord 131, and educated in anatomy and medicine at Alexandria, then the most famous school in the world. At the age of thirty-four he settled at Rome, where he distinguished himself as a skillful practitioner, and became the physician to the Emperor Marcus Aurelius. The period of his death is not known, but it is stated that he was still living in the reign of Septimius Severus. Galen was a voluminous writer. A considerable number of his works are lost, and yet eighty-two treatises, more or less complete, survive and are in print. The writer of this sketch felicitates himself in the possession of a fine copy of the "Editio Princeps," in five ponderous folios, printed in Greek, by the celebrated Aldine press, at Venice, 1525. For a period of nearly fourteen centuries this vast mass—more voluminous than the entire Bible—was copied and recopied with the pens of scribes! Who can duly appreciate the value of the press? Galen proved that the arteries are blood-vessels, and thus destroyed the error of Erasistratus. He said, when an artery is opened, blood alone gushes out and no air. He tied an artery at two places a little distance apart, and on opening the vessel found it filled with blood only. The followers of Erasistratus wanted to know how the air from the lungs entered all parts of the body, to whom Galen replied that the air entered the lungs to cool the blood, after which it was expelled. This theory was held so late as the last century, even by the renowned physiologist Albrecht von Haller. Galen declared the pulse to be the

dilatation of the artery by the contraction of the heart, which is the truth.

Galen also taught that there are two kinds of blood, the *spiritual* blood of the arteries and left ventricle, and the *venous* blood of the right side of the heart and veins, the red and the black blood. These were great strides in the right direction, and yet this wonderful genius was the author of some grave errors. He believed it necessary that a certain portion of spirit should be mixed with the venous blood to render it fit for nutrition, and this he conceived took place by the transmission of arterial blood through little holes in the ventricular septum which he called "foramina." He taught that the arterial blood nourished organs of a light and delicate texture such as the lungs, while the venous blood nourished the grosser organs, such as the liver.

The early modern anatomists believed the septum was perforated, and saw with the eyes of faith the "foramina" on account of their unquestioning confidence in the infallibility of Galen as an authority. Mondinus, who flourished in the fourteenth century, the first anatomical writer after Galen, said the septum was perforated, and twenty others reiterated it.

Berrenger de Carpi, who wrote and published his anatomical work in 1521, was the first to waver, and say that the openings in the septum *were only to be seen with difficulty.*

That I may pass no one who has been credited by any writer with even the least knowledge of the circulation, or who has even hinted a better understanding of it than those already mentioned, I come next in the order of time to NEMESIUS, who was Bishop of Emissa, a city of Phœnicia, at the latter end of the fourth century. He was not properly a medical writer, though he wrote a treatise concerning the "Nature of Man." The editor of the Oxford edition of this work (1671) contends that Nemesius understood and described the circulation of the blood in plain terms; while Dr. Freind, in his "History of Physic," denies that he had anything more than a vague notion of this function. I copy the words of Nemesius as translated by Freind for the benefit of the curious:

"The motion of the pulse takes its rise from the heart, and chiefly from the left ventricle of it; the artery is with great vehemence dilated and contracted, by a sort of constant harmony and order. While it is dilated, it draws the thinner part of the blood from the next veins, the exhalation or vapor of which blood is made the aliment for the vital spirit. But, while it is contracted, it exhales whatever fumes it has through the whole body, and by secret passages. So that the heart throws out whatever is fuliginous, through the mouth and the nose by expiration."

Thus it appears that Nemesius had a little insight of the circulation 1,500 years ago, yet so imperfect that he neither comprehended it himself nor made it understood by any who followed him.

ANDREAS VESALIUS, OF BRUSSELS.—The next great actor on the stage, comes the renowned Vesalius, the Luther of anatomy, the bold and defiant reformer, who, by persevering diligence and pains-taking observation, corrected the numerous errors of all his predecessors, and notably those of Galen. This wonderful young man, before he attained the age of thirty, published the most extensive, accurate, and in every sense the most magnificent work on human anatomy the world ever saw; wealth was lavished on its illustration and sumptuous publication. Jan Stephan van Calcar, the favorite pupil and wonderful imitator of the world-renowned Titian (not Titian himself, as some have declared), was employed to design anatomical figures, and the best engravers cut them in wood to adorn that massive and splendid old folio—that *opus magnum*, which was published in Basel, in the year 1543, three and a third centuries ago.

It is the delight of the medical bibliomaniac to procure a good copy of this rare book. The writer of this essay sought vigilantly for a score of years, failing to secure it until quite recently, and then from the library of a deceased friend, who was an ardent lover of the medical classics. He too had sought in vain for this book, and at last, after long rummaging the dusty and mouldy antiquarian book-stalls of many an ancient city in Europe, laid his hands upon a fine copy of the "Corporis Humani Fabrica," which he ever after regarded as the gem of his collection, as it certainly now is (almost sacred by melancholy association) the greatest treasure of my own. I wish we had time to stop just here, that I might give you a sketch of the life of Vesalius. Henry Morley, Professor of English Literature in the University of London, has written a lively and lovely little biography of this great anatomist, which is far more fascinating than any romance.

The great Vesalius, justly styled "the father of modern anatomy," subjected the septum, between the right and left cavities of the heart, to a thorough scrutiny, and found that no holes existed in it, and then had the boldness to declare the truth in spite of the previously unquestioned authority of Galen, whose writings were sacred in the estimation of all physicians. Thenceforth anatomists ceased to believe and teach this great error which Vesalius dispelled and swept away, and thus it came to pass that the second great step was taken toward the discovery of the circulation of the blood.

On the 27th day of October, in the year 1553, on a hill not far from the old Swiss city of Geneva, could be seen a motley gathering of anxious and excited men, women, and children, and among them a goodly number of learned doctors of divinity, chiefly Protestants, conspicuous among whom was John Calvin, all assembled to witness a scene of extreme horror. There stood, lashed to a post, a scholar past forty years of age, who in his time had imbued himself in the learning of three professions—law, divinity,

and medicine. Of his attainments in jurisprudence I know nothing; of his anatomical and physiological knowledge I will say more anon, merely premising that it was truly marvelous and in advance of the times; in theology, according to the opinion of Calvin and others, he was a heretic, since he entertained antitrinitarian notions. He had written two books, the respective titles of which are, "De Trinitatis Erroribus" (1531) and "De Christianismi Restitutio" (1533), which latter he had the frankness to send to Calvin for corrections and suggestions. Calvin denounced it promptly to Cardinal Touron as heretical, whereupon the cardinal laughed heartily at one heretic accusing another. It has been said, and it is to be feared with too much truth, that John Calvin was stirred not so much with holy zeal or fanaticism as by hate, as he had received a letter from this medico-legal theologian, now tied to the stake, awaiting the horrid tortures, and death, by slow fires about to be kindled at his feet, which letter animadverted, perhaps not very sweetly, upon the errors and absurdities of Calvin's "Institutes." This letter, be it understood, was in reply to a violent one which Calvin had written to this poor victim concerning his opinions. Time will not allow me to tell the whole story of how Calvin vindictively threatened him, and drew up thirty-eight articles of accusation against him, and how the poor, unfortunate man fled and disguised himself, and was subsequently arrested and tried by a grave council of sixty, who, after deliberating three full days on his heresy and the degree of punishment to be inflicted, fixed upon a heavy fine, and death by slow, torturing fires; and that all his manuscripts and copies of his works were to be burned with him and to furnish a part of the fuel with which to execute this fiendish sentence. Yet so it came to pass that this unfortunate scholar expiated his crime of heterodoxy in this tragical manner, and so effectually was the order for the burning of his works carried out, that only a single copy of one of his books is now believed to be in existence, and that is not a little scorched by fire.

You may wonder who this poor victim was, and why he is introduced here in a sketch of the history of the discovery of the circulation of the blood.

It was Michael Servetus, whose Spanish name was Miguel Servede, born in the year 1509, at Villanneva, in Aragon near Saragossa, in Spain. He was educated, as before hinted, in three professions, in jurisprudence and theology in the University of Toulouse, in medicine at Paris. He practised as a physician, and wrote at least one medical treatise. He also wrote, most unfortunately, two theological books, one an abstruse metaphysical work, already alluded to, "The Restitution of Christianity," which, though it ended in his ruin, contained words and ideas which have immortalized his name. Of this wonderful book a copy exists in the Bibliothèque Impériale at Paris, of which M. Flourens, Perpetual Secretary of the Academy of Sciences, proudly says,

"I have seen, I have touched, the book of Servetus!" He then goes on to state that it is perhaps the only copy now in existence; that it belonged to Colladon, one of the accusers raised up by the pitiless Calvin against the unfortunate Servetus; that this copy formerly belonged to the celebrated English physician Dr. Richard Mead, and was afterward purchased by the Royal Library of France at a very high price. In it, says Flourens, Colladon has underscored the passages upon which he accused Servetus; and that, finally, as a last mark of undeniable authority, several pages of this unlucky volume are scorched and blackened by fire. It was not saved from the pile where author and work were burned together until after the conflagration had commenced.

In this rare book is contained the first account ever written of the pulmonary circulation. I will not stop to quote the exact words as I have them in translation, but will briefly state that, in plain and unmistakable language, he declares that all the blood is sent by the contraction of the heart from the right ventricle through the pulmonary artery into the lungs, where it is changed from dark to red in color by the atmospheric air, and thence returned to the left side of the heart through the pulmonary veins—which is strictly true. Servetus denied the old doctrine of Galen, that the liver was the seat of sanguification, and declared it to be the lungs.

Thus it is seen that, long before the day of Harvey, there was a man of genius occupied with this great subject of the circulation of the blood, and that man was Michael Servetus.

I will add but a word to this sketch, already too long, in explanation of the occurrence of these physiological considerations in a metaphysical treatise of this kind. Servetus was discussing the Scriptural assertion that the soul is in the blood, that the soul is the blood itself; and hence, as Flourens states the case, "'Since the soul is in the blood,' says Servetus, 'to know how the soul is formed it is necessary to know how the blood is formed; and, to learn this, we must see how it moves.'"

But Servetus was not equally clear in his views of the general or systemic circulation. "He speaks confidently of the nerves being continuations of the arteries, and describes, with grave precision, how the air passes from the nose into the ventricles of the brain, and how the devil takes the same route to lay siege to the soul."[1]

Realdo Columbus (1544–'77).—This celebrated anatomist, one of the best of that illustrious line which gave glory to the medical school of Padua in the sixteenth century, was a native of the city of Cremona, which is about fifty miles from Milan, in Italy. He flourished about the year 1544, and was a pupil of the renowned Vesalius. Columbus made several important discoveries and improvements in the knowledge of anatomy. He rediscovered the *pulmonary circulation*

[1] "*Blackwood's Edinburgh Magazine*, August, 1858, p. 151.

six years after Servetus's ill-fated book was printed, and unquestionably without any knowledge of what was in it; for it does not appear that the discovery by Servetus was known to the world, or produced any influence whatever upon any individual, owing to the character of the work in which it appeared, and to its thorough destruction by fire.

The description which Columbus gives of the circulation of the blood through the lungs is very complete, clear, and concise. "Between the two ventricles is the septum through which it is believed the blood passes from the right to the left; but this is a great mistake, for the blood is carried by the *arterial vein* into the lungs; thence it passes, with the air, by the *venous artery*, into the left ventricle of the heart, which no one has yet seen."

His work, "De Re Anatomica," was published in 1559. Columbus died in 1577.

ANDREAS CÆSALPINUS (1519–1603).—This third aspirant for the glory of discovering the pulmonary circulation was born at Arezzo, thirty-eight miles from Florence, Italy, about the year 1519. He was an eminent philosopher, a celebrated botanist, and a distinguished physiologist. He was for many years a professor at Pisa, and subsequently called to Rome, where he also professed, and received the appointment of first physician to Pope Clement VIII. He spent the last years of his life in Rome, where he died February 23, 1603.

The great naturalist Linnæus styled Cæsalpinus the first systematic writer on botany, and followed his classification in many particulars, making it the basis of his own. The history of the physical sciences gives more than one example of the discovery of an important fact by two or more persons, in different places and at different dates, each without previous knowledge of what the other had observed. So do we find it in this instance. Cæsalpinus rediscovered the pulmonary circulation without knowing that both Servetus and Columbus had each previously and independently discovered the same, for he nowhere alludes to them; and he was too noble and honorable a man to bedeck himself with glories not his own.

Moreover, this man was the first who ever employed the felicitous and expressive words, "the circulation of the blood."

"This *circulation*," said he, "which carries the blood from the right heart through the lung into the left, corresponds perfectly with the disposition of the parts. For each ventricle has two vessels: one by which the blood arrives, and the other by which it departs. The vessel by which the blood arrives at the right ventricle is the *vena cava;* that by which it leaves is the *pulmonary artery.* The vessels which pour the blood into the left ventricle are the *pulmonary veins;* the vessel which affords it exit is the *aorta.*"

No man can describe it more accurately. But Cæsalpinus did not stop here. He was the first and only one before Harvey who gave the

world any idea of the circulation of the blood through the entire body. He pointed out the familiar fact that the veins swell below and not above the bandage tied around a limb, which demonstrated that veins return the blood to the heart and not toward the external parts of the body. He also says, "The blood conducted to the heart by the veins receives there its perfection, and, this perfection acquired, it is carried by the arteries to all parts of the body."

Certainly no man can describe the general circulation more concisely or better than this.

Thus it appears in evidence that, over half a century before Harvey's discovery, Andreas Cæsalpinus lifted the veil which concealed the mysteries of Nature, sufficiently to obtain quite a clear understanding of both the lesser and the greater circulation of the blood.

His countrymen are determined to proclaim his priority, and contest the claims of Harvey for the right to wear the laurels, as will appear from the following extract taken from a recent medical journal:[1]

"A monument in honor of Andrea Cesalpino was unveiled in the University of Rome, October 30, 1876, with imposing ceremonies. The Italians claim for Cesalpino the merit of having discovered the circulation of the blood more than fifty years prior to Harvey's discovery. Dr. Giulio Ceradini, Professor of Physiology in the University of Genoa, seems to have been the orator of the day, and he recommends that over the entrance of the Pisa school, where Cesalpino first taught his discovery, there be placed the following inscription: 'Andrea Cesalpino, of Arezzo, Lecturer on Medicine in the University of Pisa, after the correction of Galen's errors as to the function of the liver and the veins, discovered the circulation of the blood through the whole body, which circulation he made manifest by vivisections after ligatures had been applied to the veins, and which in his "Quistioni Peripatetiche" and "Quistioni Mediche," published in 1569 or 1593, using the word "circulation" itself, he fully described. Ill-advised was the English Harvey, who, in 1628, dared to arrogate to himself the discovery of this mighty truth.'"

Hieronymus Fabricius ab Aquapendente (1537–1603).—Jerome Fabricius was very celebrated in his day. The republic of Venice settled upon him a yearly stipend of a thousand crowns in gold, and honored him with a statue and a golden chain; but his immortal honor consists in having discovered the valves of the veins, the anatomical proof of the circulation, and in having been the teacher of Harvey.

He discovered the valves of the veins in 1574. He saw that they open toward the heart, and that the blood could only move in that direction, the reverse of what takes place in the arteries, which have no valves. Fabricius saw the fact, but did not understand the proof it furnished that the blood moved in a continuous circuit.

The March and April numbers of the American reprint of the London *Lancet*, of 1877, contain two little articles, by Sampson

[1] New York Medical Journal, December, 1876, p. 667.

Gamgee, entitled "Harvey and Cæsalpinus: an Historical Fragment," from which I learn that Prof. Ercolani, of Bologna, has brought forward another claim for the great honor of discovering the circulation, and has urged with so much erudition and persistence, on behalf of Carlo Ruini, that, *in memoriam*, a marble tablet adorns one of the halls of that ancient seat of learning. It would appear that Senator Ruini's work, "Anatomia del Cavallo," published at Bologna, in quarto, 1598, and at Venice, in folio, 1599, had but a limited circulation, and remained comparatively unknown. Dr. Gamgee says: "This marvelous passage, so far as I know, never attracted attention until my friend Prof. Ercolani set it forth, with justifiable national pride." I regret that Dr. Gamgee has not copied "this marvelous passage."

I will pass Fra Paolo Sarpi, theologian and anatomist, born at Venice in 1552; and La Vasseur, a disciple of James Sylvius, the very worthy master of Vesalius, and in turn his fiercest adversary—to both of whom has been attributed the honor of having discovered the circulation of the blood. Their claims rest on uncertain data, a critical examination of which would be out of place in an essay of so brief and popular a character as this; hence, having alluded to them, I will proceed to the so-called "immortal Harvey," on whom all English writers bestow the glory of having first discovered the circulation, and first published to the world the demonstrations of the great fact.

William Harvey (1578–1657).—I will be brief in my sketch of the crowning hero of the story of the circulation of the blood. William Harvey was born of a highly-respectable Kentish family, April 1, 1578—wanting one year of three centuries ago. Great men have chiefly come of superior and noble-minded mothers. I cannot pass the quaint and lovely moral portrait inscribed on the monumental tablet, in Folkestone Church, believed to have been written by Dr. Harvey himself:

"A. D. 1605, Nov. 8th, dyed in y^e^ 50th yeere of her age, Joan, wife of Tho. Harvey. Mother of 7 Sones and 2 Daughters.

A Godly harmless Woman: A chaste loveing Wife:
A charitable quiet Neighbour: A co'fortable friendly Matron:
A p'ovident diligent Huswyfe: A careful te'der-hearted Mother.
Deere to her Husband: Reverensed of her Children:
Beloved of her Neighbours: Elected of God.
Whose Soule Rest in Heaven: her Body in this Grave:
To Her a Happy Advantage: to Hers an Unhappy Loss."

This man, so noted in physiological science as to be generally spoken of as the immortal or the divine Harvey, occupied in his time many positions of trust and honor. He was physician to St. Bartholomew's Hospital, London; Professor of Anatomy to the College of Physicians; one of the physicians of King James I., and subsequently physician in ordinary to "the most illustrious and indomitable Prince

Charles I., King of Great Britain, France, and Ireland, Defender of the Faith." He was with this king at the battle of Edgehill. Much of his time was occupied in attendance at the royal court, and yet he found opportunity to follow the bent of his genius in anatomical and physiological researches.

Being wealthy, he remembered the necessities of his profession, and munificently bestowed money in the erection of a fine edifice for the College of Physicians, enriched it with a fine pathological museum and library, and endowed it with funds, wherewith, as a part of the bestowment, an annual oration is delivered for the advancement of medical science.

But to return to the subject under consideration: methinks I hear you ask, after the foregoing recital of what so many observers have discovered, "What remained for this great man Harvey to discover or explain?"

Dr. Rolleston[1] answers: "Nothing less than *the circulation itself.* His predecessors had but impinged, and that by guess-work, upon different segments of the circle, and then gone off at a tangent into outer darkness, while he worked, and proved, and demonstrated, round its entire periphery."

True, as Flourens says, when Harvey appeared, everything relative to the circulation of the blood had been indicated or suspected; nothing had been established. Servetus knew nothing of the general circulation; Columbus adhered to the Galenic error of the origin of the veins in the liver; Cæsalpinus, who perceived the two circulations, and came so near to comprehending them, still held belief in the error of perforations in the ventricular septum; and, lastly, Fabricius—who, by-the-way, was not the very first to discover valves in the blood-vessels, but who discovered more of them than any other observer, and wrote more and better than any of his predecessors—Fabricius, I say, did not understand the use of the valves, supposing them to be for the purpose of strengthening the veins and checking the too rapid flux of blood through them.

The medical historian Sprengel has cunningly remarked that nothing explains Harvey better than "his education at Padua," under the teachings of Fabricius.

If it was a piece of good fortune for Harvey to enjoy the teachings of Fabricius, it was a happy thing, and a thrice fortunate thing, for the world, that the study of the circulation should have fallen into the hands of a man so well fitted to investigate it and to elaborate the true theory of the motion of the heart and blood.

Before Harvey, it was not known that the heart is the motive power—it was presumed to be the lungs; he it was who demonstrated every step in the progress of the blood in its double circuit, stilled all clamor of disputants, and convinced the world that he was right.

[1] "Harveian Oration" for 1873.

Let every man who has in any manner contributed to the final discovery have his just proportion of credit for what he has done, but let no man try to rob Harvey of the glory, which is rightfully his, of having perfected our knowledge of this wonderful function, modestly, lucidly, and with great forbearance and dignity, in view of the unkind opposition and even vindictive hatred which his teachings engendered.

John Aubrey,[1] who was at Harvey's funeral, and "helpt to carry him into the vault," tells us he had heard him (Harvey) say "that after his booke of the circulation of the blood came out, he fell mightily in his practice; 'twas believed by the vulgar that he was crackbrained, and all the physitians were against his opinion and envyed him."

I cannot follow the history of the opponents to Harvey's new doctrines. I will mention a few of the most potent, beginning with Primrose, of Scotland; Parisanus, of Venice; Caspar Hoffmann, the learned and laborious professor of Nuremberg; Joannes Veslingius, professor at Padua; and end with Riolanus and Guy Patin, of Paris. Neither will time permit me to more than mention a few of the powerful defenders and promulgators of this new doctrine, as it was always called, among whom were Roger Drake, his own countryman; Werner Rolfink, professor at Jena; Renatus Descartes; Sir George Ent, his biographer; and Peter Dionis, who taught it in the *Jardin du Roi* by order of Louis XIV.—all praise be to this King of France.

Dionis says, "I was chosen to demonstrate in your royal garden the circulation of the blood and the new discoveries, and I acquitted myself of this duty with all the ardor and the exactitude which the orders of your majestie deserve."

All this looks as if the predecessors of Harvey had failed to discover or to teach the true motion of the heart and blood. It was twenty-three years after Harvey's publication that Italy, which now claims the entire credit of the discovery, admitted the truth of the new doctrine; and about the same time John Pecquet, of Dieppe, and Thomas Bartholin, the Dane, gave in their adhesion to the new doctrine, and spread it far and near in their writings. The victory was complete when Plempius, of Louvain, who had fought Descartes so valiantly, made the following retraction:

"This discovery did not please me at all at first, as I publicly testified both by word of mouth and in my writings; but, by-and-by, when I gave myself up with firmer purpose to refute and expose it, lo! I refute and expose myself, so convincing, not to say merely persuasive, are the arguments of the author; I examine the whole thing anew and with greater care, and, having at length made the dissection of a few live dogs, I find that all his statements are most true."

Harvey knew nothing of the capillary vessels; these were demon-

[1] Aubrey, "Lives of Eminent Persons," 8vo, London, 1813.

strated by Marcellus Malpighius, who was born the very year that Harvey's work was published, 1628.

I will conclude my long story by merely mentioning the discoveries of the lacteals, the receptacle of the chyle, and the lymphatics.

Harvey discovered the circulation in 1619, and published it in 1628. Aselli discovered the lacteals in 1622; Pecquet the receptacle of the chyle in 1648; Rudbeck and Thomas Bartholin the lymphatics between 1650 and 1652. This was a glorious period indeed!

Thus it came to pass that the united labors of all these worthy men—and labors they were, and worthy men were they—resulted in giving the world a simple, clear, and satisfactory solution of the manner of the circulation of the nutrient fluids of the body.

Next all-fools-day will be the tercentenary of Harvey, when all Christendom ought to be interested in the justice of his claims to the glory of consummating a discovery of so much consequence to mankind. No mere national pride should bias the minds of men whereby memorials may be placed at Rome, Pisa, and Bologna, in rivalry with that which is to be erected at Folkestone, in England, to commemorate the time and place of Harvey's birth.

## OVER-CONSUMPTION OR OVER-PRODUCTION?

By O. B. BUNCE.

WHY does the prevailing business depression continue? Why are the times so "hard?" Why is the long-hoped-for revival of trade so backward? What is it that has put the times so disastrously out of joint?

Every one is asking these questions, and nearly every one is ready with an answer. Some will declare that the trouble is all of the greenbacks; others will go so far as to affirm that the lack of greenbacks is the cause. Almost every one will assert that over-speculation has something to do with it; some will attribute the whole mischief to the intense railway "craze" of a few years ago, and the consequent losses. Not a few are confident that extravagance and over-trading are the explanation. There seems to be no general agreement of opinion; even men of equal business knowledge and experience differ essentially in their views as to the genesis and remedy of the evil, and the professors of political science are scarcely nearer of accord.

There has recently come from an eminent English authority in political economy an authoritative declaration in the matter. No one will deny that Prof. Bonamy Price's essay denominated "One per

Cent."[1] is eminently readable; the professor knows how to give literary grace and vivid interest to a theme commonly considered "dry;" it is further true that anything he may utter on the topic is entitled to great respect and consideration. At the same time there is no reputation so exalted that the assertions and arguments made public under its sanction should not be and may not be examined and tested. Now, to our mind Prof. Price is often logically wrong in his essay referred to; we can but think that many of the reasons he assigns for the great business depression—which now prevails in America, England, and Germany—are fallacious and misleading, and, with all modesty, it is our present purpose to give the reasons why.

The title of "One per Cent." is given to Prof. Price's article because one per cent. has been for some time the ruling rate of discount in the London money-market (just as from two to three per cent. has been for many months the quotation for call loans in Wall Street), funds in the hands of bankers being in excess of the needs of borrowers and traders. Trade is curtailed, production restricted, stagnation is evident in every branch of industry, and this general paralysis causes in the financial centres such a flow of money that it is offered to loan at an almost nominal discount.

The cause of this wide-spread depression, according to Prof. Price, is one, and one only—"over-spending, over-consuming, destroying more wealth than is produced. This," he says, "is the real *fons mali*, the root of all the disorder and the suffering, the creator of the inevitable sequence of cause and effect. Men have acted as a man who farmed his own land and had consumed not only the portion of the crops which were his true income . . . but had himself and his dependents devoured a portion of the seed-corn and the breeding-stock, had exchanged a portion of the produce which was required for wages in the coming year for foreign luxuries, or had consumed these necessary reserves on an excess of drainage, however valuable in itself and ultimately enriching."

This is the core of Prof. Price's argument. The prostration of trade has arisen from extravagance, he repeatedly declares. "The commercial depression, so long, so monotonous, so heavy, and so dull, came from the excessive consumption of English capital in unwarranted constructions beyond savings, and unwarranted expenditure in living by all classes, which destroyed wealth without repairing it with new productions."

But elsewhere he says: "Up to the extent of the savings of the nation, expenditure on railways can do no economical or financial harm; and these invaluable developers of wealth may on such a basis be rationally acquired for the public good. Any outlay made out of savings, be what it may, is innocent of mischief; it may do no good,

[1] *Contemporary Review*, London, and reprinted here in THE POPULAR SCIENCE MONTHLY SUPPLEMENT, No. 1.

but it does not impoverish. But what are savings? The surplus of wealth made over wealth consumed. If it is turned into capital and applied to increased production, the nation becomes richer; if it is expended on any luxury or any folly, the nation is where it is." These declarations no one, we imagine, will dispute.

But Prof. Price, in attributing business stagnation to extravagance, to "over-spending and over-consuming," assumes the whole question. He produces no evidence whatever in support of the attestation. He does not show that consumption and expenditure have exceeded production; he declares that capital has been impaired, but gives no facts nor figures in support of the affirmation. The whole groundwork of his theory is boldly and flatly assumed, without the slightest regard whether there is evidence to support it or not. It is grossly illogical to assume that there is over-spending simply because to casual observation there is high and extravagant living. A class may be extravagant; a group of people may be impairing their capital; but where are the figures to show that the English people as a whole have been indulging in undue excesses, have reduced the sum of their savings, "by which the means of producing are diminished?" There is absolutely nothing whatever upon which to base these assumptions! Prof. Price tells us in another place that "her (England's) producing power, her fixed capital, her machinery, remain unchanged," and that "she is compelled to shut up many of her factories, to dismiss or put on half-time immense numbers of her working-people, because there are fewer buyers of the articles they manufacture." This, he declares, is the very pinch of the matter. Indisputably it is, but whether fewer buyers is the consequence of over-consumption or of some other cause is also the pinch of the philosophy of the matter —and this let us ascertain, if it is possible to do so.

How is it, if the savings of a country have been really impaired, that capital at the same moment should be seeking investment at any rate of interest it can command—that all the financial centres are choked with an excess of money, for which it is impossible to find borrowers? Assuredly, loans at a low rate of interest imply an excess of capital over the needs of trade or production; it shows that business operations are restricted, for whatever reason, and have released capital from its ordinary uses to such an extent that it accumulates in trade-centres, seeking for borrowers that do not come. It can make no difference whether we call money capital or not; it cannot affect the heart of the question what it is that is offered at one per cent.—gold, notes, assets of any kind—whatever money may really be, it would seem clear that, if over-consumption had impaired the capital of the country, those individuals who could come into the field as lenders would be enabled to dictate terms to the needy borrowers. Over-consumption means a destruction of food, clothing, coals, metals, etc., to an extent that impairs the reserves of these

products; but it must be a marvelously extensive over-consumption that impairs the means for restoring them—that renders it impossible for fixed capital—machinery, furnaces, shafts—to be set in productive operation.

Can Prof. Price give an instance where any civilized nation, unless at war, or suffering from some great calamity, has impaired its capital by over-consumption? Can he name a period when, at the end of any year, with the exceptions mentioned, England has possessed less wealth than at the beginning of that year? When, in modern times, have a people impaired their capital by over-consumption? When and where has extravagance brought a community to ruin? Where are the instances? What are the occasions? Who can produce the statistics that will establish this theory? Not but what there may be, and often are, hurtful extravagance and speculative excesses; but these are usually special to a class. The great body of a people are rarely consumers to the extent they are producers; quietly, in a million of minor ways, the wealth of a country increases even in times of depression. We find current in the journals a paragraph which affirms that last year the valuation of property in England, exclusive of London, increased $14,335,000—too little, no doubt, but something different from the destruction of more wealth than is produced. Very rarely, indeed, if ever, has the capital of a country in normal periods of peace been really impaired, however much distress an imperfect distribution of labor and of profits may have caused.

Let us say here that the ordinary idea of national extravagance—meaning excessive expenditure by the people, and not governmental expenses—is peculiarly erroneous; an assertion we confidently make, notwithstanding the fact that Prof. Price accepts the usual theory. He declares that "a nation is only an aggregate of individuals," that "analysis will always resolve the action of the single man, and the combined coöperation of a host, etc., into the same constituent parts;" that is to say, over-spending and over-consumption are of the same nature, whether exhibited by an individual or a community.

Now, we think it can be shown that expenditure in the case of an individual and expenditure in case of a large group of individuals have certain very essential differences. When a community exchanges its goods for foreign luxuries to an extent to impair its productive capital, or has invested in railways or similar enterprises so as to reduce its working capital, it is in the position of an individual who has lived beyond his income. But the difference between an individual and a community is, that the income of the former is absolutely fixed, that of the other is wholly expansive. In truth, in an immense number of things, a *community is rich because it consumes, abundance being the product and consequence of extensive destruction.*

It is evident that the immense consumption of coal has made coal cheap and abundant. It has rendered possible the employment

of vast capital in the erection of costly machinery for the working of the mines, for the construction of adequate means of transportation, thereby making remote deposits accessible, and enabling capitalists to work the mines at the minimum of cost, which never would have been done had not the vast consumption of coal rendered it wise and practicable to do so. It is true the consumption of coal is increased by cheapness; but it is only by extravagance, so to speak, by free and extensive use of coal, that the machinery by which it is made cheap is put in operation. We have an immense wealth of coal because we consume coal so extensively; if we used but little we should have little, and this little would be dear.

This rule works in all or nearly all our staples. Cotton fabrics are a marvel of cheapness and abundance. The consumption and the possibilities of extended consumption have stimulated invention and industry so greatly that the world has become wealthy in its supply of this staple alone. Rarely, indeed, is there a woman so poor that she cannot own a calico gown; few are the men so destitute as to be without cotton shirts. We have this staple in almost unlimited abundance, as the direct result of the most extended consumption. It is the same thing with wool, with flax, with paper, with iron, with brick, with many other things.

So peculiarly different is the operation of expenditure with a community from that of an individual, that it is worth while to trace it still further. Let us suppose a town about to erect a grand cathedral, or some other public structure that requires a very large quantity of stone. At first flush it would seem as if a great deal of valuable material would be used in a purpose unnecessary and unproductive; but, as a practical fact, the building-material is likely to become more abundant and cheaper than it ever was before. The unusually large consumption of stone would lead either to the opening of new quarries or the erection of improved machinery for working the stone, and to the construction of railways, boats, etc., for facilitating its transportation; so that stone for building purposes would thereafter be cheaper and more abundant as the consequence of what at first sight appeared a wasteful consumption. In all staple things, at least, a nation is richer because it consumes, while a man is richer by what he saves. We are better housed, better fed, better clothed, we have a thousand things of taste and pleasure, because our eager and devouring appetites have stimulated energy, skill, invention, to their utmost to cater for us.

We say nothing as to which is the wisest direction for consumption to take, with all it stimulating power; we do not deny that consumption may make champagne, diamonds, silks, broadcloth, fine furniture abundant, at the cost of more useful and desirable things. The thing is simply that the energy, the zeal, the exertion of men are so expansive, that great demand compels to great production; and, of course,

we understand the economic principle that there can be no production without capital; that if the working reserves of a community are really impaired, the productive force is also straitened.

It will be said that consumption is rather the product than the cause of abundance. Undoubtedly, use is greatly increased by abundance; there is, in fact, action and reaction, the one stimulating the other. It will also be adhered to by some that capital is the sole source of production. Assuredly capital is not fixed in activity, nor are human energies rigidly limited; and as the resources of Nature are fairly boundless, wealth is wrought out of her bowels in our mines, and extracted from her chemistry in our fields, to an extent immensely determined by the demands of consumers. In the old fable of the purse of Fortunatus a gold piece appeared as rapidly as the contents were withdrawn; in the new purse of Fortunatus, called production, two or more pieces appear as rapidly as one is withdrawn; but we must not lose the purse, which let us consider as capital.

There is something more to be said about national extravagance. What is it that railways, and bridges, and canals, and fine buildings, cost? We hear continually the money-price mentioned. This is most misleading. The price paid is simply a sum of money that has changed hands; it represents the cost of the structures to those who built them, but not the cost to the community. What is this cost? What does a church or a railway cost the people as a whole? Some have paid wages, and some have received wages. This is only diffusion. Some money has gone for stone, iron, and timber, but this is only diffusion. The community is less this iron, stone, and timber,[1] but we have already seen that, as the production of this material is unlimited, no practical loss is inflicted here. It is asserted by all economists that food and clothing for the laborers are part of the cost. But the laborers would have been fed in any case, although they might have held on to their old clothes longer, had not the wage-fund been distributed among them. Now, to our mind, the real cost of this church or railway is the cost of the energy that might have been more profitably employed elsewhere. If all the productive industries are in full operation; if it is released labor, and the material is not required for more necessary purposes, then it cannot be shown that the church and railway have impaired the wealth of the community at all—that is, it cannot be shown that they have fundamentally cost the community anything. They were erected by released energies, by labor not otherwise required, and the community is not the poorer by a mite in consequence of their construction. A church may be a very extravagant undertaking for those who pay the money-price for it; the

[1] An exception must be made with timber. We are, in America, encroaching upon the forests, and hence consumption is now making this staple dearer; but, when all our hill-sides are covered with *planted* forests, the normal rule will operate in this product as in others.

railway may be a foolish and unremunerative enterprise; but this has to do with the individuals concerned; the community, in the supposititious cases we have made, *might*, let us suppose, have been better off had the expenditures of those individuals taken some other form, if the material and the labor had gone into something productive (let us believe there are other good things in the world than economic production); but no injury, no loss, no diminution of wealth has occurred—and this is the main thing. A passage quoted from Prof. Price in the earlier part of our article affirms this.

We hear a great deal about the railroad "craze" of a few years ago, and of the immense sums sunk in those foolish and extravagant ventures. But the sums of money commonly mentioned are misleading. As we have fully explained, the money simply changed hands; what was really lost by those enterprises was the goods and bullion exported to pay for the iron purchased abroad, and the food and clothing consumed by the laborers, over and above what their consumption would otherwise have been; in addition to which is the loss of the misdirected energy. This was all very large, no doubt; but far from being what the figures commonly quoted represent it to be. There is, moreover, no evidence that this loss was anything more than a part of our surplus; the assumption that it impaired our capital, and depleted our productive resources, is wholly groundless. No one can say, we imagine, that capital was withdrawn from any other pursuit; that productive industry in any direction was weakened by a secession of its resources by this "craze." The nation was much in the position of a merchant who has many ventures abroad, some of which have proved disastrous. His profits are reduced, but his ability to keep his numerous ships afloat is not impaired. Even had the railroad investments partially reduced our capital, it is really monstrous to assume that we could not have recovered from the blow in much less than four years of time. Whatever the cause of the business prostration may be, it evidently is something that lies deep, something far more serious than the loss of a part of our wealth. A merchant who loses all his profits is still enabled to go on; a merchant who loses even half of his capital is still enabled to go on: how is it, then, that the community is so nearly at a standstill because a portion of its surplus was lost? Distinctly the railway over-speculation, hurtful as it was, cannot account for the paralysis in industry which now, four years afterward, so generally exists.

Not a few people are convinced that paper-money is the cause of the difficulty. "Only return to specie payments," they say, "and all will be right." All the inflation and unhealthful stimulation caused by the greenbacks has ceased to be. It was predicted that a reaction must come upon the return to specie payments. It has come long before. It has come without contraction of the currency, the volume of which has ceased to exercise that hurtful influence that was supposed to

be inseparable from it. It may be asked, moreover, if the currency is the cause of our suffering here, how is it that a similar condition of business affairs exists in England, where the currency has remained unchanged? There is no doubt in the world that an inflated currency does have a hot-house effect upon trade and production, and, as with all forced things, a corresponding reaction follows; but it is wholly inadequate to account for the present difficulty, although it has doubtless contributed toward it.

What, then, is the real cause of the evil? In endeavoring to answer this question, we shall probably startle not a few well-established convictions; but we bespeak a fair and patient hearing.

Almost any practical man of business, upon being asked what the trouble is, would attribute it to over-production. To this the economist promptly exclaims that there can be no such thing. "What," he would say, "over-production! too much wealth! an excess of prosperity! The thing is impossible. No people ever yet was made poor by an excess of wealth, by a superfluity of goods." This seems very plausible; but, if the economist is pressed, he will admit that there may be, and often is, over-production in certain things—that more may be produced of special articles than there are goods of other kinds to exchange for them—but general over-production is, he will reaffirm, impossible. Inasmuuch, however, as production is fairly never general, never uniformly active, there is always over-production in some branches of trade; and it so happens that this over-production is commonly coupled with great centralization of wealth and enormous appliances of machinery.

We must not be understood to utter a word against the power, the advantages, the immense boon of machinery; but, as all things have their compensations and their penalties, so machinery, beneficent and marvelous as it is, is one means of bringing about certain unfortunate consequences, as we think may be demonstrated.

Production and consumption do not have that intimate relation to each other they once had. In old times the weaver, for instance, was in contact with his customers: he wove cloth as he discovered the need; he cautiously set up a second loom when it became fully evident that it could be kept employed; and thus supply and demand went, as it were, hand-in-hand. But now gigantic mills filled with many spindles have little accurate relation to consumption. The power of production by means of improved machinery is something immense, and it is exercised with no very watchful or cautious regard to the immediate needs of the community. Goods are piled up in vast quantities in waiting for a future market, or for an anticipated change in price; or they are pressed upon the market at such low rates or on such long credits that buyers are seduced into over-purchases. In favorable times these establishments are run at high pressure. The old-fashioned nice relation between producer and

consumer disappears. Speculation takes the helm. Much more is produced than there is corn, leather, or other goods, to exchange for it. The resources of the mills are great; they can borrow from the banks while they pile up their fabrics in their ware-rooms; they can by means of their concentrated capital keep their machinery running, even at a loss, if by so doing they can crush out a rival or manipulate the market.

But in the height of this prosperous run there is a check—no matter for what cause—and suddenly the work stops. There is little sale for goods produced; the fires must be put out, the doors closed, and thousands of operatives are deprived of employment. This would not be so unfortunate if this over-production had been diffused among the work-people. But it had not. Notwithstanding the high pressure and the excessive manufacture, wages have been kept down; while producing in six months as much as could be exchanged in a year, the workmen have not been paid in this way—their wages have been upon the basis of the whole year's work—as a result, they are turned empty-handed upon the street. And, what is particularly unfortunate, they are reduced as consumers to the minimum point. Here the evil works both ways. The excessive production which has shut up the mill has weakened the power of the community to absorb this production—the goose that laid the egg has been slain.

Inevitably the recovery from hard times brought about in this way must be slow. The spindles cannot be set in motion until the stock of goods on hand is reduced and a fresh demand revives; this demand cannot revive because the great body of consumers are in a state of impoverishment. This condition of things is entirely sufficient to explain the genesis and the prolongation of business prostration. Capital is not impaired: it is locked up in machinery that is silent, in goods that cannot be exchanged, in money that has no borrowers. It is the paralysis of consumption that is the cause; and this paralysis has been brought about by an unregulated production, by an excess that is not diffused, by the stoppage of wages, by the idleness enforced upon those who would be consumers, by the absence of an adjustment of production to consumption. Is it not clear that we must have a regulated production; that machinery with its magical facility must be put in check; that we must restore the old cautious and intelligent relation between the two factors of supply and demand?

We read lately a very angry denunciation of a combination between certain mine-owners in Pennsylvania to limit the production of coal. Why? If these men are attempting to make an artificial scarcity, it is wrong, and all attempts of this kind fail; but if they mean simply to regulate the marketing of coal—of coöperating so that an excess of the article shall not be thrown upon the market, and prices forced below cost—they are right. It is better for them to

do this than in the heat of competition overstock the market, and then be forced to stop the works altogether, throwing all the miners out of employment. We should say that combination is just what is needed—so that the supply of material may be kept nearly on a par with the demand, and the mines uniformly worked at a sustained rate from one season to another. Spasmodic production is a dreadful evil. It is unfortunate for the consumer because it makes prices uneven, and it inflicts cruel injury upon laborers and operatives, and through them upon the whole community.

Here, then, is the evil. Speculation inflames it; currency inflation stimulates it; but undiffused, unregulated, and unrestrained production throws the whole complex machinery of trade out of order; it stirs the whole energies of the people into producing at one period, and arrests energies at another; in suddenly stopping production, it reduces consumption, and hence renders recovery the very labor indeed of Sisyphus. The only remedy we can discover is the wise coöperation of producers, the determination to put the production of goods in careful and just relation to the means possessed by the community for exchanging for them.

We hear recently a great deal of the example of France, and Prof. Price is among those who point admiringly to her in this crisis. Now, as every one knows, the savings of people in England, Germany, and America, are deposited in banks, whence they are loaned and become utilized as capital; in France the peasants hoard their savings in old stockings and secret corners. To withdraw from either of the former countries so large an amount as that of the indemnity paid Germany would greatly disturb trade; but the peasants, patriotically unearthing their hoardings of secret gold in exchange for government bonds, enabled the state, to the surprise of all, to pay her heavy penalty without distress or financial disturbance. But this was an exceptional position. We are scarcely to argue therefrom that hoarding is the true principle; that a nation is better off because its work-people hide their savings, withdrawing them from public use, rather than placing them in banks where they may become active capital. Prof. Price attributes the successful payment by France of the German indemnity to "the practice of one of the very greatest of economical virtues—she had saved." Now it was solely due to the *manner* in which her savings had been held. The fact seems to have dazzled everybody. The example of the French peasant is now held up on all sides—that he lives the narrowest and most restricted of lives; that his excessive economical spirit not only limits his comforts, but keeps him ignorant, superstitious, dull, spiritless, hopeless (the tragedy of the French peasant-life is only too well told in the pictures of Millet); that he has neither intellectual life nor any grace of art or refined civilization—these facts are nothing to the economist; the peasant has drudged and hoarded; he has refused himself and

his family ease and comfort, and hoarded; he knows neither art, nor literature, nor science, but he has hoarded; he lives a life scarcely better than that of the beast of the field, but he has hoarded; his savings have nourished no industries, nor rewarded any art, nor promoted any intellectual end, and he himself has done his best by mere restriction to limit the productive resources of his land—but having saved and hoarded with the instinct with which a dog hides a bone he is held up for admiration! This sort of thing fully explains the shudder with which people generally hear the name of political economy. It is true, there must be economy; there must be saving; but there is economy and economy. The real cause of the more prosperous condition of France is not starved existence but sustained and unspeculative production. There is less concentration there, less wild overtrading; there are more diffusion and old-fashioned relation of production to consumption.

This equable and uniform production is like a stream that is fed by ten thousand springs and many affluents; it flows steadily on, calm, perennial, beneficent: but our speculative and spasmodic production is too much like a mountain-river, that at one season comes down in a flood and deluges the land, at another subsides into a rivulet, and all the land is parched.

## ATMOSPHERIC PRESSURE AND LIFE.[1]

By Dr. PAUL BERT,
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THE great influence that may be exerted upon living beings by atmospheric pressure is now questioned by none, and there is even a disposition to exaggerate its importance. If the barometric column rises or falls a few millimetres, nervous people affected with the asthma perceive phenomena, whether of a beneficial or of a noxious kind, which they do not hesitate to attribute to the weight or to the lightness of the atmosphere. But if this were the only cause of their sensations, then they should experience the same symptoms whenever they subject themselves to equal variations of pressure, as in passing from the level of the sea to a point only a few feet above it, or *vice versa*.

Rarefied Air.—As every one knows, in proportion as we ascend from the sea-level, the barometric pressure diminishes at the rate of about one centimetre per 100 metres of vertical ascent. And this diminution is progressive: suppose that at the sea-level the pressure is 76 centimetres, then it will be 66 centimetres at the height of 1,123 metres

[1] Translated from the French by J. Fitzgerald, A. M.

(summit of Vesuvius), 56 centimetres at 2,432 metres (pass of the Great St. Bernard), 46 at 3,998 metres (Mont Pelvoux), 39 at 5,920 metres (the height of the highest pass of the Himalaya is 5,835 metres). The greatest height attained by man was reached by Glaisher in a balloon — 8,840 metres, pressure 24.76 centimetres — and by the brothers Schlagintweit on foot, in the Himalaya, 6,882 metres, pressure 32 centimetres. The highest mountain on the globe, Gaurisankar, measures precisely 8,840 metres—the elevation at which Mr. Glaisher fell fainting to the floor of his car.

Such modifications of pressure cannot be endured with impunity by the human organism. Though life in moderately elevated regions, as the Jura and Auvergne, seems to be so beneficial to those who dwell there constantly, that multitudes come thither from afar in pursuit of health; and though in regions situated at a greater altitude, as the admirable plateau on which the city of Mexico stands, the sum of the climatic conditions seems to offer hygienic advantages: still all are agreed that at very great elevations there always supervene, with more or less intensity according to persons and circumstances, certain characteristic perturbations and discomforts described by travelers in the Alps, the Pyrenees, the Andes, and the Himalaya.

These are, first, a sense of fatigue out of proportion to the amount of walking or of work performed. The legs appear to become leaden, and one feels a weakness in the knees. Then the breath becomes short, difficult, labored; the pulse is quickened; the heart-beats occur isolatedly, and reverberate in the head. Next come singing in the ears, dimness of sight, and vertigo. The general sense of *malaise*, the feebleness, become such that the traveler must rest, else he will fall to the ground. Simultaneously there occur other symptoms having their seat in the digestive organs, such as nausea and vomiting. These various symptoms, taken together, constitute mountain-sickness (*mal des montagnes*), which bears a resemblance to sea-sickness.

When they first appear, a few moments' rest suffices to banish them; this instantaneous restoration of strength and vigor sharply distinguishes mountain-sickness from ordinary fatigue. But at greater elevations, where graver symptoms appear, such as bleeding from the nose or from the lungs, repose cannot bring back the condition of perfect health, though it always affords some relief. Travelers agree in saying that a person on horseback suffers far less than one on foot. On the high plains of the northern Himalaya, a rather brisk pace in walking, the ascent of a hill however low, the carrying of a moderately heavy load, suffice to exhaust one's strength, to cause him to faint, and in some cases even to produce death.

This is the reason why aëronauts are attacked much later than those who ascend the mountain-side. Ever since the day when Montgolfier, realizing the immemorial aspirations of the human race, gave to man the means of overcoming the gravity which ties him to the

earth, many a bold aëronaut has gone above the clouds. Only after they have reached the height of 6,000 metres do they usually experience symptoms resembling those of mountain-sickness.

But on land these symptoms make their appearance at elevations far lower, and differing according to locality. In the Alps, definite symptoms first appear at 3,000 metres; in the Bolivian and Peruvian Andes, at 4,000 metres; higher still, in the equatorial Cordillera and on the Himalaya. In general, the elevation at which they first appear depends upon that of the line of everlasting snow, the lower limit of mountain-sickness being situated a little above the snow-line. The influence of the temperature is very evident. As for anomalies special to circumscribed localities or to individuals, the consideration of them would take us beyond the bounds we have set for ourselves here.

These grave and curious symptoms have been explained in many different ways by travelers, physicians, and experimenters. As for the native mountaineers, they solve the problem of their origin by referring them either to supernatural intervention or to the influence of noxious effluvia. In the Andes these effluvia are reputed to be of an antimonial nature; in the Himalaya the cause is supposed to be vegetal poisons given forth from flowers, mosses, etc. These hypotheses need not detain us.

Among the many theories more or less tenable *a priori*, but none of which will stand the test of experiment, there is one which is almost universally accepted, and which reckons De Saussure among its distinguished supporters. It is known that the atmospheric pressure on a square centimetre of surface is 1.03 kilogramme. If we multiply this by the number of square centimetres of surface in a man's body, the product is something enormous. Take an average case, a pressure of say 15,000 kilogrammes. We are in equilibrium with this great pressure, they say; lessen the pressure, and the result is like the application of an immense cupping-glass over the entire surface of the body. The heart's action is now no longer sufficiently counterbalanced, and hence congestion and hæmorrhage of the mucous membranes and of the skin, engorgement of the blood-vessels of the face, cerebral troubles, and the rest.

It is amazing to find a theory so plainly at variance with elementary physical laws accepted by eminent men. What would be the result if we had to bear upon the surface of the body a pressure of 15,000 kilogrammes, and if every variation of the barometer added or subtracted from this sum one or two hundred kilogrammes?

Another theory, first offered by De Saussure, is far more worthy of attention. "On the top of Mont Blanc (4,810 metres)," says he, "the air is nearly one-half less heavy than at the sea-level; hence it results that if, in a given time, we pass through our lungs a given volume of air, that volume will represent only about one-half the weight of the same volume of the air to which we are accustomed. Hence there

must result insufficient respiration, or, more accurately speaking, insufficient absorption of oxygen." "The quickening of the respiration, which tends to offset the evil, is insufficient," says Martins, "for it would have to be twice as frequent, and have double amplitude, in order to compensate the diminution in the quantity of air inspired." Finally, Dr. Jourdanet adds that, "the pressure being reduced, the oxygen must be dissolved in the blood in a less proportion:" hence a pathological state analogous to anæmia, and which he calls *anoxyhæmia*.

These ideas have been met with many objections. In reply to De Saussure it was said that the atmosphere, even at half-pressure, contains a great deal more oxygen than is needed for respiration; and in reply to Jourdanet that, according to the researches of Fernet, oxygen in the blood being in the state of combination, and not of solution, its quantity does not depend on barometric pressure.

My own experiments show that De Saussure and Jourdanet are right. They further prove the sagacity of Jourdanet in recognizing in the inhabitants of the Anahuac plateau the injurious influence of low pressure which, though not perceptible in the state of health, reveals itself on the slightest attack of disease. I need not detail here the long series of experiments which have led me to conclude that the symptoms following diminished pressure, whether slowly or rapidly applied, are simply the result of a diminution of the oxygen in the blood; in a word, that they are nothing but a sort of asphyxia in the midst of the "pure and invigorating mountain-air."

Still I may repeat here an experiment which can be performed wherever we have a pneumatic apparatus; this experiment clearly proves that the lessening of the barometric pressure is of no account, mechanically, in the production of the phenomena. These are the result rather of chemico-physical action, the blood not being sufficiently charged with oxygen.

We place a sparrow in the pneumatic bell-glass *A* (Fig. 1), which communicates with the manometric tube *C E*. The pressure is gradually lessened by means of the tube *B*. When the manometer shows only 30 centimetres' pressure in the bell-glass, the bird gives pretty serious evidence of suffering; at 20 centimetres it totters, reels, and falls upon its side; at 18 centimetres it struggles violently, and would die in a few seconds, were I to leave it in this situation. So I quickly place at *a* an indicator, to show the height attained by the mercurial column, and, opening the cock *D*, I introduce into the bell-glass not air, but oxygen from the India-rubber bag *O*. At once the bird becomes himself again. I let it breathe a little while, and again I diminish the pressure as before. But now we reach 30 centimetres, 25 centimetres, without difficulty; not till we reach 20 centimetres does the bird appear to show some little signs of discomfort; we reach 13 centimetres, *a'*, a pressure much less than before, and yet the

life of the bird is plainly not at all endangered. If I were to admit oxygen once again, I might diminish the pressure still more.

Hence it appears that it is not the lowering of mechanical pressure that produces the symptoms, but the low tension of the oxygen of the

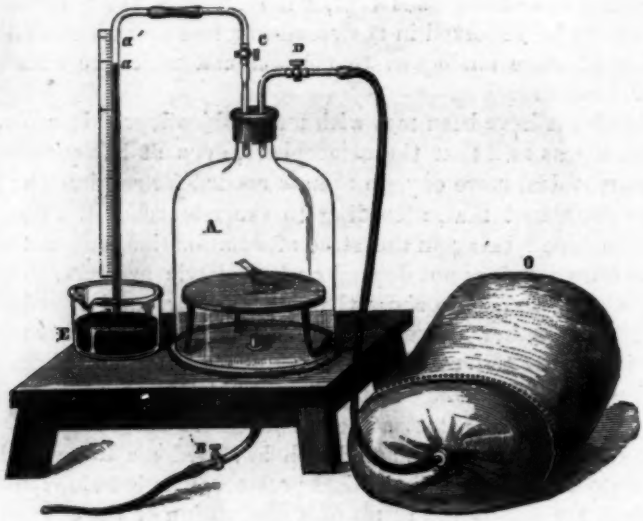



FIG. 1.

dilated air, which low tension prevents the oxygen from entering the blood in sufficient quantity.

This experiment I have made not only with sparrows, but also on my own person; and in the latter case the results are quite as striking as in the former, and I dare affirm, without vanity, no less interesting.

By the kindness and liberality of Dr. Jourdanet, I have been enabled to set up in the physiological laboratory of the Sorbonne great apparatus, by the aid of which I have studied the effects of compressed and dilated air. The dilated air-chamber consists of two cylinders of riveted sheet-iron, from which the air is gradually exhausted by means of a steam-pump (Fig. 2).

This apparatus I have entered, taking with me a large India-rubber bag filled with oxygen. As the pump began to work, I experienced all the well-known symptoms of mountain-sickness, viz., quickening of respiration and pulse, which was considerably augmented by the least movement; sense of loathing, nausea, sensorial and intellectual perturbation. I felt indifferent to everything and incapable of action. On one occasion, having counted my pulse-beats for one-third of a minute, I tried to multiply the number of beats by three, but could not do it, and so was obliged to write on my bit of paper, "It is too difficult."

But all these symptoms disappeared as by enchantment so soon as I respired some of the oxygen in the bag; returning, however, when I again breathed the air of the cylinder.

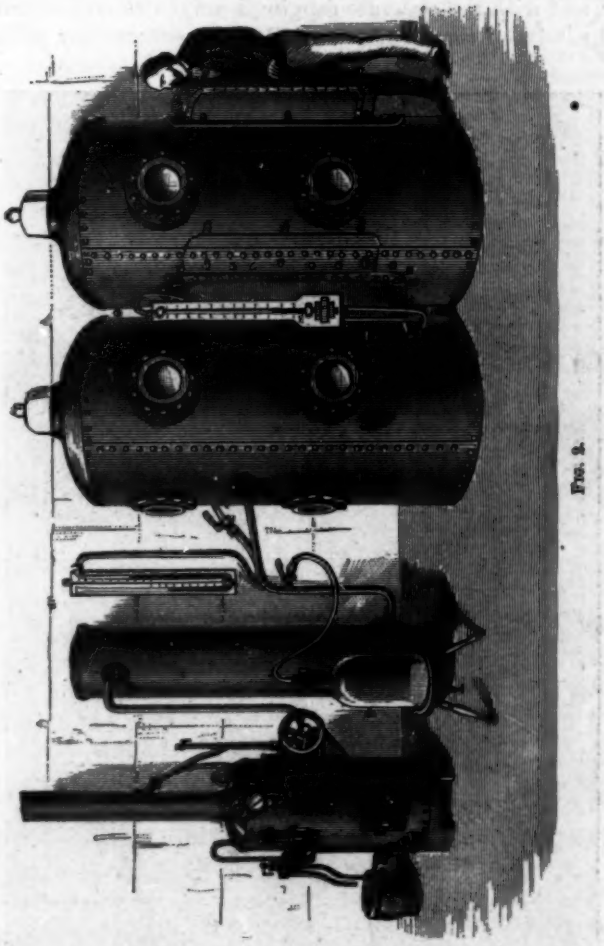


FIG. 2.

Fig. 3 gives the details of one of these experiments. In this figure the times of the different stages of the experiment are given at the foot: just above this is seen the curve which represents the rate of pulsation; and above this another curve, showing the barometric pressure in centimetres: the figures in the left-hand margin represent the changes of pressure and pulsation. It will be seen that, as the pressure is diminished, the pulse is accelerated. Thus, the pressure being 42 centimetres (answering to the elevation of Mont Blanc), the pulse-rate, which at the beginning of the experiment was 60, rose to 84.

At this moment I took two or three inhalations of oxygen, and at once the pulse fell to 71. Then I omitted the oxygen, and moved a little, when the pulse rose to 100, falling again to 70 when I returned to the oxygen. Ten times during an interval of one hour and twenty minutes, and with the pressure ranging between 40 and 50 centimetres, I at will produced these sudden oscillations, causing my pulse instant-

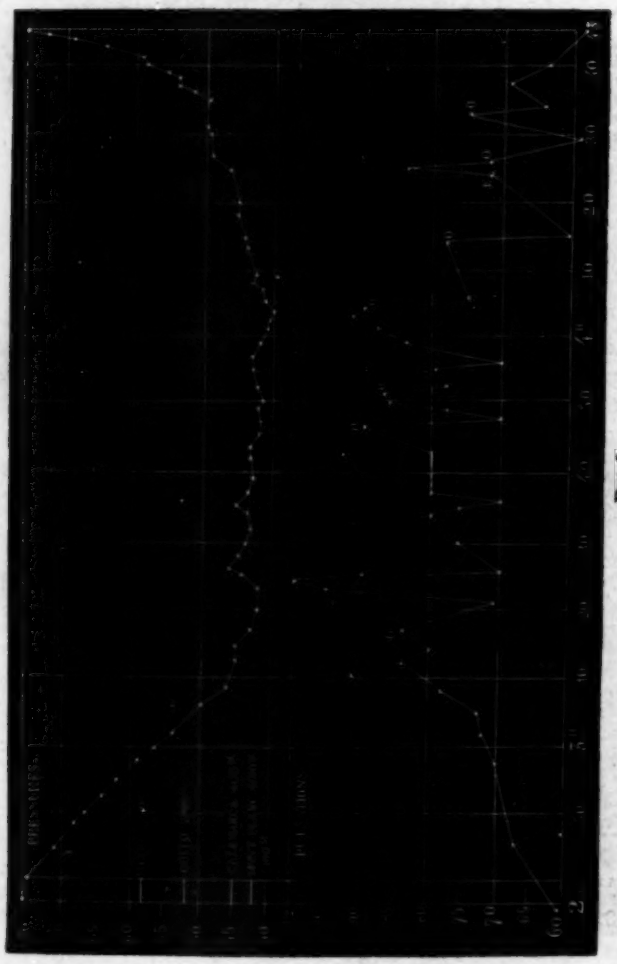


FIG. 3.

ly to rise or fall 20 beats. I may add that this is an experiment which I do not mean to repeat, having suffered during that evening slight congestive symptoms, which I attributed to these sudden changes of cerebral circulation.

On the other hand, those experiments in which oxygen is respired continuously are not followed by any injurious effects. Fig. 4 states

the results of that one of my experiments in which I reached the lowest degree of pressure. My pulse had grown more frequent, having risen from 60 to 85; the pressure was then only 40 centimetres. I now began to inhale oxygen from the bag, and at once the pulse fell to 65, at which point it stood during the remainder of the experiment, and at last even fell to 48. In the mean while the pressure had fallen to 246 millimetres. This is exactly the pressure on the highest

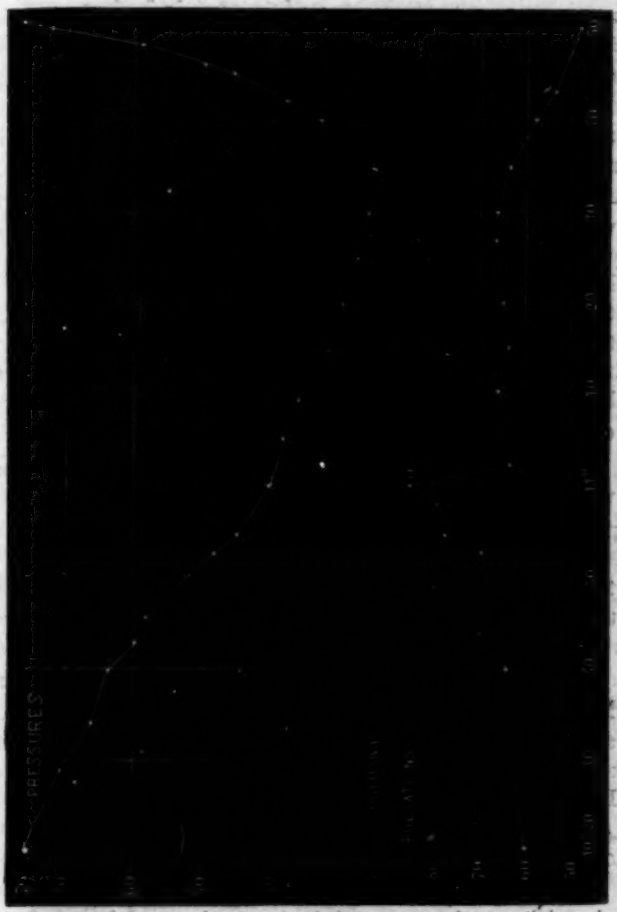


FIG. 4.

summit of the Himalaya—the same degree of pressure which was so near proving fatal to Glaisher and Coxwell; I reached this point without the slightest sense of discomfort, or, to speak more accurately, the unpleasant sensations I felt at the beginning had entirely disappeared. A bird in the cylinder with me was leaning on one side, and very sick. It was my wish to continue the experiment till the bird died, but the steam-pump, conspiring, as I suspect, with the people

who were watching me through glass peep-holes, would not work, and so I had to return to normal pressure. I placed, for a moment, the oxygen-tube under the beak of the bird, and at once he recovered.

Two other persons have, like myself, entered these cylinders, experiencing the same symptoms, and deriving the same benefit from the use of oxygen: these are Messrs. Crocé-Spinelli and Sivel. Crocé, who was very sensitive to reduced pressure, had turned black at the lips and on the ears, and could hardly see his paper, when he decided to have recourse to the oxygen. The effect was instantaneous, both upon him, who at once was able to write, and upon me, who observed with some anxiety the purple color of his ear, and was about to let in air.

Fresh from these experiments, Crocé-Spinelli and Sivel made their ascension of March 22, 1874, during which they rose to the height of 7,500 metres (a pressure of 30 centimetres). The faintness, the disordered vision, and the nausea, disappeared every time they "drank a little oxygen," as Sivel would say.

On the 15th of April, 1875, they made another ascension, in company with Gaston Tissandier. I was not then in Paris, and hence could not, as on the former occasion, superintend the making of the oxygen-bags. I would surely have made them larger, but probably I should no more than any of you have dreamed of what was the true cause of the catastrophe which followed. The oxygen-tube hung at a certain height above their heads, and, knowing that they had but very little of that gaseous cordial, they economized it against the moment when they should be more seriously attacked by sickness. But, when they wanted to take hold of the tube and to apply it to their mouths, their arms were paralyzed.

This terrible occurrence ought to be a lesson of prudence, but it must not serve as a pretext for discouragement. Crocé-Spinelli and Sivel died at 8,600 metres, with a pressure no greater than that reached by me without the slightest shadow of unfavorable symptoms, and it will be easy to devise measures which will insure the aëronaut against an attack of sudden paralysis. As for the value of ascensions to great heights, I am surprised to see it questioned by eminent men. What could be a more curious object of inquiry, from the point of view of the meteorologist, than that aërial zone, 10 or 12 kilometres in depth, in which are developed rain, hail, and snow storms? It is not wise to assign limits either to human activity or to the usefulness of scientific researches.

But to return to the theory of the symptoms produced by *decompression*. The experiments made in the cylinders demonstrate, beyond the possibility of doubt, that these symptoms depend solely on the tension of the oxygen in the air respired; an aëronaut breathing common air (21 per cent. oxygen) at one-half common atmospheric pressure is precisely in the same condition as a man who, at normal

pressure, breathes air that holds only one-half the normal proportion of oxygen. Consequently, he is subject to conditions of insufficient oxidation, and threatened with asphyxia. Hence his rapid respiration, in the effort to introduce into the blood the oxygen which is lacking; hence, too, the accelerated palpitation of the heart, and nervous and muscular debility.

But if the traveler whose blood is thus impoverished keeps perfectly still, he will not suffer much, for it needs very little oxygen to support the body in the state of immobility. But if he stirs about, if he tries to lift the weight of his body by climbing, then he has need of more oxygen than is contained in the blood; and, as this is not to be had, the symptoms of mountain-sickness make their appearance, and the only hope of relief is in repose. This is the reason why aëronauts, who perform no work, experience "balloon-sickness" at a far greater elevation than mountain-climbers experience the symptoms to which they are liable.

The cooler the air, the earlier the appearance of the symptoms. When it is warm, the traveler needs only a small quantity of oxygen to keep up the bodily temperature. But, when the air is cold, the loss of bodily heat increases, and hence the need of a more intense calorific oxygenation. But how can this be attained if the blood does not contain enough oxygen? This is the reason why, as I have already stated, mountain-sickness makes its appearance much earlier in the Alps than in the Himalaya.

Compressed Air.—For thirty years, physicians, following the footsteps of Junod, Pravaz, and Tabarié, have made use of compressed air in the treatment of sundry diseases, and they have produced remarkable results in cases of anæmia, passive hæmorrhage, chronic bronchitis, and emphysematous asthma. This I merely note in passing. Among the physiological phenomena, all observers have noted a diminution in the number of the heart-beats and of the respirations, and an increased amplitude of the latter. Physicians commonly employ a pressure of only one-third or one-half of an atmosphere, while I have specially studied pressures of several atmospheres.

These great pressures have been employed in various industries for a few years past, but more especially in submarine diving and in sinking piers for bridges.

In submarine diving, the diver incloses his head in a metal helmet with glass eye-pieces. Into this helmet, by means of a pump, compressed air is driven with force sufficient to expel it again through special orifices. Thus there is established an equality of pressure between the water around the diver and the air he breathes, and this is the *conditio sine qua non* of his being able to live beneath the water. Lead-weighted shoes and a water-proof dress complete the outfit. Messrs. Rouquayrol and Denayrouse have made the diver independent of the lighter or vessel from which, prior to their improve-

ments, he could not wander away, and this they have done by strapping upon his back a compressed-air receiver which works very ingeniously. Divers who fish in this way for coral, pearls, sponges, etc., descend to the depth of forty metres, and the air they breathe is under a pressure of five atmospheres.

The apparatus used in erecting bridge-piers is a great improvement on the old diving-bell. The discovery of the principle involved in these is due to M. Triger, who, in 1841, applied it to the construction of mine-galleries under the Loire. Nothing can be simpler than this principle: it is employed by children when they amuse themselves by blowing into a half-submerged tube, and causing the air to issue in bubbles. The apparatus, reduced to its simplest expression, may be described as follows: A tube of the length proposed for the pier is let down to the bottom of the river. It is capped with a chamber, into which is forced compressed air. This air expels the water from the lower end of the tube, and passes out just as in the child's play. The workmen can then, by means of a system of doors, as seen in Fig. 5, descend to the bottom, and there dig for the foundation of the pier. As the soil is removed, the tube descends by its own weight; it is lengthened by the addition of successive sections, till the solid rock is reached. The cylinder is now filled with *béton* and the pier is complete.

In these apparatus workmen have also been subjected to pressures as high as five atmospheres.

Now, both among divers and workmen in these tubes, symptoms have been noted often so serious as to terminate fatally. First there is an intolerable itching, called by the workmen "the fleas" (*puces*); then violent pains in the muscles and joints which have done most work; paralytic symptoms, particularly in the lower limbs, which often are persistent and fatal; finally, sudden death. Of 160 men employed on the foundations of the St. Louis (Missouri) Bridge, thirty were seriously attacked, and twelve died.

You are welcome to all the hypotheses invented by the fertile minds of physicians to explain these redoubtable troubles. Quite as a matter of course, we find here, first of all, the mechanical explanation: "When a man enters the tube," says one author, "he is *flattened out!*" (*aplati*). Very likely, indeed, if we admit that at the pressure of three atmospheres 4,500 kilometres more weighs upon our body. But, happily, we are saved from this fate by elementary physics.

The workmen in the tube at Kehl had a saying, as is usual among workmen everywhere; it is one full of acuteness and depth: "You pay when you leave." It is *decompression* and not compression that does the mischief.

But how does decompression act? Very simply indeed. Here in this glass jar is a rat subjected to ten atmospheres. I now turn a

cock, and in a moment bring the animal back to normal pressure; he turns around two or three times and drops dead. Were I to make an autopsy now, I should find the heart and the great vessels full of gas; so great is the amount, that once I drew off fifty cubic centimetres of

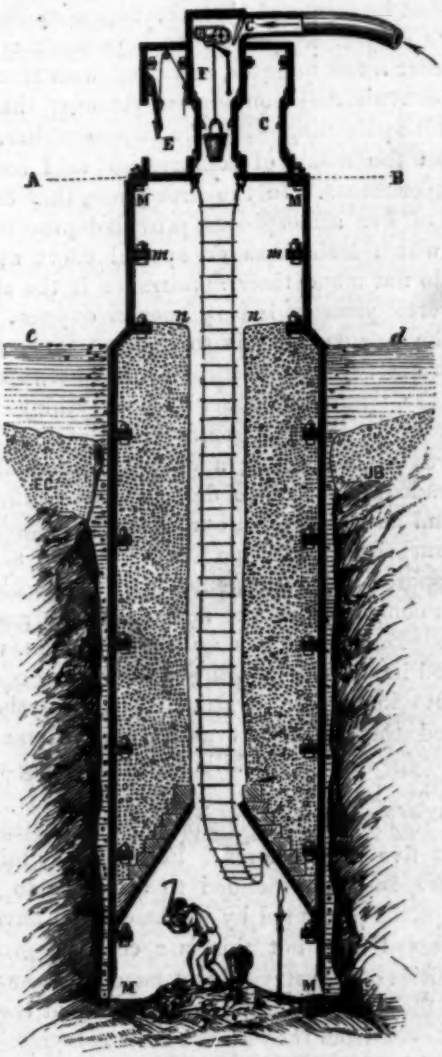



FIG. 5.

gas from the vessels of a cat *decompressed* in this way. This gas is nitrogen with a little carbonic acid.

The process is as follows: The animal by breathing compressed air charges its blood with air in the proportions indicated by physical

law; on the normal pressure being restord, the gases with which it was supersaturated pass into the free state. It is like drawing the cork of a bottle of beer. The oxygen combines on the spot, but the nitrogen is at once set free, and carries with it carbonic acid in becoming disengaged. Death is explained by the arrest of the circulation.

But it must not be supposed that the action of compressed air is harmless. If we subject a sparrow to a pressure of twenty atmospheres, it will, after a few minutes, be seized with tremors, increasing to most violent convulsions—convulsions stronger than those of tetanus or of strychnine-poisoning—and the bird soon dies. These terrible symptoms are not the result of compression, as I have been able to prove by two experiments. In the first place, they can be produced at the pressure of five atmospheres, provided pure oxygen be used instead of air, which latter has no special effect at this pressure. Secondly, they do not make their appearance if the air subjected to twenty atmospheres' pressure is very poor in oxygen.

Thus it is the oxygen that is to blame. Oxygen at too high a degree of tension destroys animal life. Long I hesitated to characterize as a poison the "nursing father" of everything that lives, but there was no help for it. Oxygen, which gives us life, slays also, when administered in too strong a dose. I have had to study thoroughly this paradoxal poison to determine the different effects of varying doses, and its action upon our tissues.

Here a new surprise awaited me. Having seen a sparrow killed by oxygen, I supposed that this agent must have accelerated organic combustion, thus consuming all the material which goes to maintain the animal heat. But great was my astonishment when the thermometer indicated in animals laboring under strong convulsions a fall of several degrees in the temperature. The analysis of other phenomena confirmed this first observation, and led me to the strange conclusion that oxygen in excess kills by interfering with, arresting, the intra-organic oxydation.

The effects of this powerful agent begin to be distinctly felt at the pressure of about five atmospheres. Perhaps they might be noticed at a lower pressure, and I am inclined to attribute to this cause the unfavorable symptoms presented by workmen who have spent several months in compressed air; but this is a complex problem. In any case, if the necessities of industry subject men to pressures higher than six atmospheres, they will be in danger not only at the instant of decompression, but even from the effects of the compression.

Oxygen at a high tension kills not only the higher animals: it acts alike on vertebrates and invertebrates, animals aërial and aquatic, plants and animals, big and little, even microscopic organisms. Its effects upon the latter are highly interesting.

From the admirable researches of Pasteur it appears that the phenomena of fermentation are of two kinds. One set of phenomena

are correlated with the development of microscopic organisms; this is fermentation proper. The other set are dependent upon the action of amorphous soluble substances; this is diastasic fermentation. Now, oxygen in a state of tension arrests the former class of phenomena, but in the latter class it is without any action.

Thus we can entirely prevent the fermentation of must, the souring of wine, the putrefaction of meat, etc., by means of oxygen in the state of tension. This work once done, we may restore the normal pressure, and then, provided germs from without are excluded, no true fermentation will occur.

I once hoped to be able in this way to preserve meats, eggs, etc., but this was an illusion. The substances do not become putrid, but, in consequence of a pseudo-fermentation, which sours them, they acquire a disagreeable taste, which takes from the process all its industrial value.

At the close of this long discourse I would call attention simply to one consideration. Atmospheric pressure acts a far more important part in the life-conditions of organisms than is commonly supposed. If we go back to the primordial geological ages, we may regard as highly probable the hypothesis that the pressure was then much higher than now. This must be taken into account when we investigate the origin of life. But, if we look to the future, it is plain that the pressure will go on steadily diminishing, just as the amount of water on the earth's surface diminishes; and hence all living things are doomed —after the lapse of countless ages, it is true—to perish by asphyxia from the lessening of the atmospheric pressure. Hence the limits of life upon the globe are fixed on the one hand by an excess, and on the other by a lack, of pressure.—*Revue Scientifique.*

## HEAT AND MOTION, AND POLITICAL ECONOMY.

THE law of the mechanical equivalent of heat may be summed up in the following propositions, viz.:

The heat required in order to raise a given weight of water one centigrade degree of temperature can also lift the same weight 1,300 feet, or, more exactly, 424 metres. Thus to the unit of heat there corresponds a definite amount of work.

Conversely, a given amount of work produces also a definite amount of heat; in other words, there is required an amount of work equal to 1,300 foot-pounds, in order to raise the temperature of one pound of water one centigrade degree.

Heat and motion, therefore, are convertible.

Chemical processes are, in the last resort, the true sources of heat.

Here only a certain portion of the heat reappears in the shape of available mechanical work, the proportion for the steam-engine being one-twentieth of the heat produced by combustion of coal, and in the human body one-sixth of the heat developed by the conversion of the bodily constituents.

Every one knows what a revolution this law has brought about in physics and mechanics: it has added a new chapter to physiology.

There is only one science which, so far, has drawn no advantage from the discovery of the source of force and work, and that is no other than the very science of work, or political economy—in German, *Volkswirthschaftslehre*.

The grandest discovery in the doctrine of forces is as yet not even mentioned, far less turned to account, in a science whose object, nevertheless, is simply force—work.

But, then, this science is called *Wirthschaftslehre*. Surely no other name could so ill denote the thing as this, and I confess that I have always had an aversion against calling honest work by such a name. *Wirthschaftslehre* suggests ideas as remote as possible from economy—taverns and tavern-keeping. Far better is the Anglo-French term of political economy. If we must have a German name for the idea, let it be simply *Arbeitswissenschaft*—the science of work—for political economy, from first to last, has to do with nothing but human labor and its relations.[1]

But if we call this science no longer *Volkswirthschaft*, or political economy, but the science of labor, the very name will clearly show that it can rest on no other basis save the law of energy, of motion—the great law of the mechanical equivalent of heat. For work, including human work, is motion, and motion is heat. Of course, political economy does not touch on the laws of nutrition, the laws of food-substances or their transformation, for that is the province of chemistry and physiology. Political economy has to do only with the value of work, its price, and thence explains the phenomena of the market. Labor is the natural process whose social relations are known as political economy. The fundamental idea which political economy derives from labor is that of value. The production, the consumption, and the exchange of values (*Werthschaffung*, *Werthverbrauch*, *Werthtausch*), are the three principal divisions of the science of political economy.

In science there is no question that the value of a thing must express only the human labor expended on it. Price is the sum of the values that are given in order to move the will of the owner to renouncement of his right in the thing, his possession and his enjoyment of the work embodied in the thing. The idea of value requires deter-

[1] For the benefit of the reader who is not acquainted with German, it may be well to explain that in that language the ordinary meaning of the word *Wirth* is host, innkeeper; and of *Wirthschaft*, innkeeping, tavern, public-house.

mination of a value unit, for only thus can we know the value; or, to speak more exactly, only thus can we conceive the labor expended on the thing. We must be able to say, not only that labor has been expended on the thing, but also how much.

Marx was the first to essay the determination of a value-unit. This he found in a fixed term of "labor-time," usefully expended in the work. But time is no measure. The measure must be a *thing*, if it is to be cognizable at all, and such a measure is presented to us only in Mayer's law.

For, if work be equal to motion, and motion to heat, then a given amount of work (task) can also be regarded as equal to the amount of materials expended in producing the heat required for such work (motion). And hence, just as we compare a given net amount of effect from a steam-engine with the coal expended, so may we compare a certain amount of work with the amount of food expended in producing it; and since wheat contains all the essential elements of nutrition, we may compare a task with the quantity of wheat expended in performing it. Where a day's wages is paid in the shape of a day's provisions we have a crude example of the application of this theory.

Hence, as natural forces are gratuitous, the value of a thing expresses the amount of food expended in its production; and the value-unit is a fixed quantity of this food, say so much as is won by a day's work.

Exchange of values is effected with the aid of a thing in which are expressed the food-units required for its production; this is metal coin. Hence exchange-metal is both value and an index of value.

Mayer's law furthermore gives the law of wages. The workman must get back what he has expended in his labor in the shape of food; and this expenditure must be supposed to cover the cost of his bringing up and development, as also provision against old age when he can no longer work.

The idea of capital, too, and especially of the justification (*Berechtigung*) of capital, falls under Mayer's law. Experience teaches that the amount of food-material gained by labor is in excess of that expended in labor. This excess is capital in the strict sense, perfectly justified capital.

In virtue of the law of equal wages for equal work, every one, even though he does not produce (if we may so speak) food-stuffs, is entitled to the same surplus in recompense (food-stuffs) that he would have earned by work expended in the production of food-stuffs.

Perhaps it will be objected that Mayer's law applies to bodily labor, not to mental; but here, too, it holds good. The natural forces are gratuitous: it is only human labor that produces value. Now to natural forces belong not only the materials of the animal, vegetable, and mineral kingdoms, but also intellectual qualities, even genius itself.

Genius is a natural force which possesses a value only in so far as work has been expended in developing and applying it; this work produces values by consuming values.

All mental labor is at the same time brain-labor. The brain consumes a certain amount of food-material. Of course, all the other involuntary bodily movements which go on simultaneously with the brain-movements, as also the necessary periods of rest, must be taken into account in estimating the value of the products of mental labor.

Here, too, a definite amount of food-substances gives a definite quantity of (mental) work.—*Das Ausland.*

## ON HEREDITY IN NERVOUS DISEASES.

By EUGÈNE DUPUY, M. D.

THE facts which I propose to consider in this paper have been brought to light by means of the experimental method. They are very interesting, both physiologically and psychologically viewed. I shall occupy myself with the physiological aspects only, and their bearing on human pathology. Psychology is beyond my province. Moreover, I conform myself to the saying of Montaigne, that deductions are very difficult to draw in psychological science, for "*comment cognoit on la semblance de ce de quoi on ne cognoit point l'essence?*"[1]

Most of the facts observed, of hereditary transmission of nervous disorders, were put on record many years ago by my eminent friend and teacher Dr. Brown-Séquard. Some I have observed, together with him, during the years that I was his assistant, and others I have discovered quite lately.

The disorders which were inherited had all been artificially induced in animals for the sake of experimentation. Very great care was taken in all cases to avoid causes of error, and I am positive that they were got rid of completely.

It will be seen that lesions which affect not only nutrition of parts, but also the higher functions of the nervous system, can be developed by hereditary tendencies, when artificially provoked, through those nerves which minister to organic functions—belonging to the so-called sympathetic system.

It is well known that a system of nerves exists in all animals which have a circulation, and which apparently has no other functions but to control the blood-vessels, to regulate the flow of the blood through them. This nervous system is called, therefore, the vaso-motor system; it is also termed the sympathetic.

[1] How can one know the like of that of which one knows not the essence?

It has been discovered that when a branch of that nervous system is sectioned, is separated from its centre, the blood-vessel with which it is connected almost at once enlarges: its calibre increases, more blood passes through it during a given time, etc. But if, now, this separated end of the nerve is irritated, the reverse phenomena are seen: the blood-vessel contracts, its calibre diminishes. When small arteries are experimented upon, the calibre becomes so small that blood-corpuscles no longer succeed in passing through it. So that it becomes evident that that nervous system has a great function to perform with regard to the nutrition of all the parts, or rather of every organ in the body, including, of course, the central, i. e., the spino-cerebral nervous system, for the "blood is the life of the anatomical elements." The materials which compose animal bodies are endowed with properties which differ in every different tissue: for instance, we say that the muscular tissue has the property of contracting. These properties of tissues develop functions: for example, the contraction of the ciliary muscle permits correct vision; but it is evident that if the tissue does not keep up the process of nutrition, i. e., assimilation and disassimilation, which it can only do by the agency of the blood which carries to it new materials, and removes effete elements, its properties are impaired and its functions are consequently perverted. This point being understood, I proceed to relate the experiments:

If in a Guinea-pig, for instance, that portion of the vaso-motor branch which is in connection with the carotid artery in the neck, —which, therefore, regulates the blood-supply of some part of the brain, of the ear, of the face, and of the eye—be divided, or, better still, if the ganglion from which that branch springs be removed, we see that the entire half of the head of the animal, on the side on which the operation has been performed, becomes hotter, and on examining more closely we discover that the increase of heat is due to the fact that the blood-vessels allow more blood to pass through them, that the nutrition of the parts is increased, and therefore the heat also increases; and we see that the upper eyelid of the animal drops a little, being in a state of hyperæmia—that is, its capillaries are distended—that the secretion of tears is increased so that the eye is wet, that the pupil of the eye is contracted because of more blood in the ciliary system, etc. The ear also becomes hotter, and, if the animal is white, we can see that the ear which before was white, with some blood-vessels stretching across, is now become red, and presents a very rich network of capillaries, which have become apparent, being of enlarged calibre.

Now, all these phenomena may disappear after a while, except a few. The eye always remains smaller, although the blood-supply of the eyelid is more regulated; the pupil remains a little contracted, and the secretion of tears continues, and also the nictitant membrane remains in a congested state. No matter how long the animal lives,

that state of the eye persists, and when the animal dies, or is sacrificed, it is seen that this eyeball is smaller than its fellow.

If, now, such an animal were allowed to breed with another—whether operated upon in the same manner or not—it would be seen that young which are born, apparently perfectly healthy, present a few days after birth all the phenomena observed in their changed parent or parents. They have the same smaller eyes, but on both sides; the same ear thickened and enlarged, etc. The only phenomena which they do not show are those which have been transient, the increased heat and the increased sensation which depended upon the increased amount of blood present, etc.

Those young can be made to breed in-and-in for several generations—I have watched them for five generations—and always the same characteristics will be discovered in the young.

If, now, an examination is made of the parent, the first one, it will be seen that the nerve which had been sectioned, or its ganglion which had been extirpated, is not regenerated; while, if an autopsy is made of one of the offspring of any of the subsequent generations, it is seen that they all possess the nerve and the ganglion intact. The acutest or most minute microscopic examinations do not discover any difference between their structure and those of other animals of the same family and species.

If a puncture be made into that portion of the upper part of the spinal cord which anatomists call the restiform body, in Guinea-pigs, it will be seen that the animal presents at once an increased vascularity of the ear on the corresponding side; the ear becomes gorged with blood, chiefly toward the periphery; sometimes in a very short time, indeed, that portion of the ear falls off, destroyed by dry gangrene. I have the record of a case in which the ear was thus partially destroyed in less than nine hours. The eye on the same side becomes larger and protrudes; it protrudes first, and becomes larger in the course of time.

If a pair of Guinea-pigs thus operated upon be allowed to breed, and even if only one parent is thus diseased, the other being healthy, when young are born, these young always present the phenomena observed in the parents; but the phenomena just described only come shortly after their birth. It is seen that their eyeballs increase in size and protrude from their sockets, their ears after a few days become diseased, just like those of the parents, the subjects of experimentation, and drop off, eaten by dry gangrene.

When the parent or parents are sacrificed, and their restiform bodies are examined microscopically, nothing is detected but a cicatrix in the envelopes of the spinal cord, which appear a little thickened at that point, but the nervous tissue itself does not differ apparently from surrounding elements of the same nature and structure. If an examination is also made of one of the young, nothing at all is discovered.

Those young can be allowed to breed in-and-in, and always the same phenomena will be observed in each subsequent generation. I have sometimes noticed that if a male or a female belonging to any one of the successive generations is allowed to breed with another healthy animal, very generally some of the young present the same hereditary peculiarities. I have followed animals thus operated upon through seven generations.

But what is still more remarkable is the transmission of an epileptic malady artificially induced. Dr. Brown-Séquard, as is well known, has for nearly thirty years made experiments on this subject of epilepsy, and his researches have discovered an array of facts of the highest value, to lighten the obscurity which has at all times rendered the true causes of that disease unattainable. He has made the like of what renders illustrious the names of the foster-fathers of experimental physiology—a synthesis: he has produced an epileptic malady in the Guinea-pig, which presents all the characteristics observed in that disease in the human species.

Dr. Brown-Séquard found that when the spinal cord of a Guinea-pig is pricked, or a portion of it is destroyed, or one of the sciatic nerves—that is, one of the largest nerves of the hind-leg—is either sectioned or torn off from the spinal cord, the animal in the course of a few weeks develops the epileptic malady. First, after a week or a little more, all traces of the operation have disappeared, as far as the wound is concerned. When the spinal cord has been operated upon, sometimes the feeling of pain is found lacking to a slight degree on the opposite side, and exaggerated below the point of the body at which the wound has been made; but most generally no such symptoms at all exist.

When the sciatic nerve has been cut or torn away, the greater portion of the leg is paralyzed as to motion and sensation, which is natural enough, because the muscles can no longer obey the mandates of the will, being deprived of the nerves which carry them, and also the centres no longer receive impressions which formerly came from those muscles and the skin covering them, because the nerves which carry the impressions have been destroyed.

It happens, also, in this case, that those parts which are thus deprived of motion and of sensation are dragged on the ground, are easily hurt, and become inflamed and enlarged. As soon as the skin has been broken, the animal begins to eat away all the parts of its leg which it does not feel; but it cautiously stops at the very limit where sensation still persists, so that, as, out of its three toes which terminate its posterior limb, the inner one is animated by nerves which do not come from the sciatic, that one toe has preserved sensation and motion. Therefore, when all the insensible tissues have disappeared, the wound heals very rapidly, and the animal has a limb which terminates by one toe only, the inner.

But another specially interesting fact with regard to epilepsy is this, that, a few days after the operation, whether made on the spinal cord or the sciatic nerve, it is found that an area of skin on the same side with the nerve destroyed or the spinal cord injured, which is limited by the line extending from the anterior extremity of the eye to the end of the nose, thence, comprising the upper lip, running along the neck to the shoulder, and then in a straight line to the posterior extremity of the ear, and, lastly, to the posterior angle of the eye, by degrees loses certain faculties and acquires new ones. The sensation of pressure, of squeezing, of heat, cold, or electricity, of pain in a word, all disappear; only the faculty of feeling tickling persists, and that appears exaggerated. In an experiment which I made some years ago, this effect followed within two hours of the operation on the upper spinal cord.

It is seen at the same time that tickling this zone gives rise at first to involuntary twitchings in the muscles of the jaw, of the eyes, and of the nose, on the same side; by degrees those twitchings become more strong and more general, then they manifest themselves on the other side also, and after a few weeks the animal has regular convulsions after each tickling of the zone, which lastly culminate in a regular attack of epilepsy, of which the features are the following: When the attack begins, the head is drawn first, and with great violence, at times toward one shoulder, at times toward the other. This has been explained by the contraction of the muscles of the neck. The mouth is drawn open by the same cause, and the muscles of the face and of the eyes, which had twitchings, now contract violently also. At this period it would appear that the muscles of the larynx are contracted to some extent. At all events, it appears that the vocal cords are contracted, for not unfrequently the animal utters an inarticulated, unnatural, sharp cry, which may be taken for the passage of air through the obstructed larynx. It then falls. The muscles of the legs are contracted stiff, those of the chest are thoroughly so; very soon all the muscles are the seat of convulsions. Respiration, which was in no little degree impeded during the time that the muscles of the chest were rigid, now becomes more frequent but very irregular. After a while the animal recovers, and remains in a state of stupidity for some time. It is not unfrequent to observe in these epileptic seizures fits of insanity—if I may use such a term when speaking of Guinea-pigs, but that word only will make my meaning understood. When these animals have been suffering for some months, it is seen that they have fits without apparent provocation; that is to say, spontaneously.

When they recover from the epileptic taint, all the phenomena observed about the zone of skin in the neck and face recur in the reverse order; that is to say, all the different sensations return by degrees, at the same time that the hair of that region falls, and new

hair grows gradually. The fits become simple convulsions, then mere twitchings, and lastly the animal can no longer be distinguished from another healthy one but by the fact that it has only one toe at one of its hind-legs, when the operation has been performed on the sciatic nerve; and nothing whatever remains when the origin of the disease was a prick in the spinal cord.

All these different facts, of which I have just spoken, are the characteristics of an epileptic seizure in our own species. That zone of skin about the neck and face is the analogue of those areas of the body of the epileptic from which sensations of all possible natures and kinds arise a short time before the attacks, and which are called by the general name of "aura."

To make the analogy greater, let me say that, just as in man, when such an "aura" is discovered to start from such a part of the body that it can be acted upon directly, so as to be removed, the disease is cured, so also, if that zone, of which I have spoken, in the Guinea-pig be cauterized, the fits do not occur—the animal is cured.

I have given these details with some minuteness, because they show still more strongly the effects of hereditary transmission of the disease. All the young of Guinea-pigs thus made the subject of experiment do not become epileptic; Dr. Brown-Séquard has observed several. I have had occasion to observe only a very few, and I have been able to learn that the young are born healthy, apparently. Sometimes—almost always, in fact—they are born with only one toe in the hind-leg; that is the case when the parent had lost its toes in the manner that I have already stated. Perhaps two months or more after their birth—they become adult very rapidly—the same phenomena develop in those young as in their parents; to use the words of Dr. Brown-Séquard himself, "we see the gradual increase of the affection, the diminution of the sensibility in the zone, just as with the parent, the coming of a period of complete attacks of epilepsy, and then the loss of hair, and the gradual diminution of the nervous complaint." Now, it is to be observed—and this is the important feature in this transmission of disease—that in the parent operated upon the cure, when it is spontaneous (that is, when it does occur without any treatment, which is the case when the sciatic nerve and not the spinal cord has been divided), only supervenes because the alteration in the nerve is cured: if it has been sectioned, the two ends meet again and are reunited after a few weeks; if it has been torn away, the parts still remaining attached to the outer heal together; we can therefore understand how, the cause of the disease, i. e., the alteration of a nerve, being removed, the disease, i. e., epilepsy, also disappears. But in the young which have inherited the taint no such explanation obtains. Their nerves have not been operated upon, not torn nor cut. How are we to explain their cure, and this fact, which is, as I have said, the peculiar feature of this

heredity, that the cure in the parent which has so characteristic stages should have exactly the same stages in the young as to circumstances and time?

I have said that I would only deal with this subject of heredity in its physiological aspects, but I cannot refrain from recalling to the attention of the reader that such facts in the human species need to be studied by psychological physicians, because they occur in insane patients, as is well known. Those alterations of the ears of which I have spoken at first are frequently met with in the ears of demented patients; physicians call them hæmatoma. I have satisfied myself that it is even more frequent than suspected in the inmates of asylums. That state of stupor, or stupidity, and of insanity, in the Guinea-pig, is of very frequent occurrence in the human epileptic. I could tell a long story of similar phenomena observed in our own species.

I believe that, if any conclusion can at present be drawn from those facts, a physiologist or a physician will state that it is not a disease which is inherited, which is transmitted, but the *power* to develop such a disease. On the one hand, a physiologist is bound to accept that the disease was originally developed as a *consequence* of an anatomical alteration of a certain organ or nerve-cell or fibre; and on the other he is bound to consider that the same disease or *consequence* develops itself in a young one which has no such circumstances of anatomical alteration of a certain organ or nerve-cell or fibre—at least detectable by any means of investigation at present employed.

This question of heredity is one of the most vexed, and I shall not say much more about it at present; but as I have stated that I am sure that there were no causes of error in the facts themselves or the deductions drawn from them, I take this opportunity to say that Mr. Galton has committed a grave error, in his very remarkable paper on "Heredity" published not very long ago, in which he stated that the Guinea-pigs which had epilepsy without alteration induced in their nervous system may have acquired the disease by imitation, just as, it is well known, is too frequently the case in the human species.

First, all the children or adults who happen to live with epileptic patients and witness their paroxysms *do not* develop epilepsy; only a very few do so. This fact would show, therefore, that those who do develop epilepsy have some tendency; but the argument of Mr. Galton does not hold good with regard to the first two series of facts which I have reported, and specially in the case of the Guinea-pigs which inherit epilepsy. How will he account, on the strength of his hypothesis, for the fact that, out of a couple of hundreds of young which were born from epileptic parents during the lapse of several winters in Dr. Brown-Séquard's laboratory in Paris, and which I have very studiously watched, only three became epileptic, although all lived together and all witnessed the fits of their parents, and only those three

developed the malady which were born toeless? I regret, on closing this paper, not to be able to take the psychological aspect of the question, because it is very interesting in a forensic point of view, and as bearing on the question of responsibility.

## THE MATERIAL RESOURCES OF LIFE.[1]

By ALBERT B. PRESCOTT.

TO be able to live, in any way known to us, it is indispensable to have a body. And, as living bodies come by growth and continue by nourishment, it is first necessary to have materials whereof bodies can be made—and renewed and kept in warmth and strength. Just these materials, with permission of the reader, we will try to take account of, as resources of life. Life is not maintained "by bread alone;" other needful resources being known to physical science, and still other resources greater than all being recognized by their results in life; but we have the bread alone, as enough, certainly, to be considered in the present article.

Living things are in very deed made of "the dust of the earth;" but it is by no means all of the dust of the earth that serves this purpose. We have to distinguish between substances out of which organized instruments of life can be made, and a much larger number of substances never used in the making of these instruments.

We have it in mind that matter is made up of *sixty-three simples*. At all events, the earth's crust and air are constituted, substantially, of these sixty-three sorts of atoms, and, as a good many of the same are already revealed in the sun and stars by the spectroscope, it is likely that they are the chief elements in the universe of matter. Of the sixty-three, certain elements, found only in very small quantities, appear to be of subordinate importance in that part of the universe under our immediate observation, whatever purposes they may fulfill in other earths or in the centre of our own, or at other epochs. Others of the elements bear an important part in the structure of the globe or in the uses of mankind, but are not organizable materials, and they are not in our present consideration. Of the sixty-three, only *fourteen or fifteen simples*, about one-fourth of those known to us, are used in the construction of plants and animals. These, then, are before us, as the elemental resources of life.

It will be understood that the tissues are not built directly of these fourteen elements, but of *their chemical compounds*. Each one of these compounds is a definite substance in external character distinct from its constituents, as, in a familiar example, water is distinct from

[1] An address given before the Detroit Scientific Association, December 13, 1876.

the hydrogen and oxygen of which it is composed. The number of these chemical compounds built into living tissues is very great, a number uncounted. It is of these compound substances—of their molecules—that the cells are builded; builded by an action very unlike chemical action and into shapes very unlike chemical results. Also, it is by the consumption of these compounds of the fourteen elements that animal warmth and activity are sustained. But, not turning aside here to question the chemistry (the making of molecules) going on in cells, or the vital organization (the building together of molecules) going on in cells, not once lifting our eyes toward any of the dynamical sources of life, we bend our attention to find out, if we can, *the raw material for cells*, the inorganic resources of the organic world.

It is the organic world together, to be sure, that is able to subsist on the fourteen elements as these are given by the earth, the animal kingdom obtaining most of its material at second hand, as elaborated by the vegetable. The two kingdoms are, in the end, mutually dependent on each other in gaining sustenance from the earth's supplies.

The fourteen indispensable simples may be *classified*, in different ways for different ends. There is a privilege of provisional classification, for the sake of comparison and of acquaintance; and, with the promise not to impose our arrangement upon any other occasion, we would like, for the purposes of our present quest, to divide the elemental resources of life into two categories, as follows: 1. *Those supplied so abundantly on the earth that all individuals share them alike*, without favor of fortune or forethought of mind. We may name them redundant resources. 2. *Those provided so sparingly that individuals do not share them alike*, but secure them by effort and by opportunity. They may be termed adequate resources.

From the provision of the first class of materials, it results that, in certain great essentials of organization, all individuals are placed on a footing of equality with their fellows. It results from the provision of the second class of materials, that unequal qualities and quantities of organization are derived by different individuals of the same species. Through our redundant resources we are taught the common brotherhood of the created. Through our adequate resources come the assurances of our responsibility—our commissions as stewards of the earth. Materials given in a superabundance that cannot be wasted constitute a dispensation of mercy; its benefits falling alike on the just and on the unjust, the lazy and the diligent, the foolish and the prudent. Materials given in a competence that must be guarded constitute a dispensation of compensation; inciting to exertion, rewarding for attainment, and training the powers of volition. By the first, the democracy of equal privileges and inalienable possessions is maintained; by the second, the aristocracy of merit is preserved.

The redundant resources so abound that they can have no value,

in the sense of exchangeable value, in society; even though needed as they are in more constant supply than those of the other class. The resources which are barely adequate are those which come to be objects of personal possession; they are the things of which mine and thine are declared, and it is because of them that title-deeds are drawn and prices-current established. The substrata of poverty and of riches rest in the chemical elements.

With the definition of each class in mind, let us now consider the supply of some of the more important of the elemental resources. From the fourteen, let us take at least three elements of each class, as representatives. For the redundant resources, we will take carbon, oxygen, and hydrogen. Then, for the adequate resources, we will examine nitrogen, phosphorus, and potassium.

*Carbon* is the one element never left out of an organic compound. Its atoms are not only constituents, they are corner-stones of all the organic molecules. In the human body, thirteen parts in a hundred, or forty per cent. of the solids, are carbon. Looking for its supply, we see that it is obtained for the organic world by the plants, and from the carbonic-acid gas of the air. It is taken from the air chiefly by the leaf of the plant. How much carbon is taken from the organic mould of the soil and from acid carbonates, through the roots, is perhaps not fully settled; but we are well assured that the main and sure resource of the plant for this element is the air. The *supply*, then, is as abundant and impartial as the open air itself. The carbon-material forms but a small part of the air, it is true, only about five parts in 10,000; nevertheless, it is enough, at least for the average rate of vegetable nutrition. Carried around the globe in the viewless air to every plant alike, the carbon-atoms are supplied for the framework of every cell in plant and animal. A dwarfed shrub or rootless lichen, clinging to the crevices of a naked rock on a frigid shore, has at hand a good supply of the same resource that is furnished to a luxuriant palm spreading from a tropic soil.

And the carbon-supply in the air is not a reservoir diminishing, however slowly, from age to age; but, to be sure, it is a returning fountain, replenished from the exhalations of animals and the decomposing remains of all organized bodies. In Nature's economy, the same carbon-atoms are used over and over again as material for organization. This perpetual replenishment, a thrifty provision against future exhaustion, is one not peculiar to carbon, but it is a provision made in good degree for every one of the elemental resources of life, whether redundant or only adequate in its immediate supply.

That plants feed upon the carbonic acid of the air is known to the school-children, and has been known to men for a hundred and one years at least. Priestley, whose discoveries were celebrated in the chemical centennial at Northumberland, Pennsylvania, two years ago, placed it on record very clearly that "air vitiated by animal respiration is a pab-

ulum to vegetable life." This was but the next year after Priestley's discovery of oxygen itself; yet to this day there lingers in our common thought an undefined impression that the carbonic acid of the air is just an impurity, tolerated because there is only a little of it, but an impurity that it were as well to be rid of altogether. Now, if the redundant resources of life were at our human disposal, we might be in danger, some day, in the sheer forgetfulness of self-regard, of throwing away as an impurity the very foundations of sustenance. Some one, perhaps, would set forth that this gas when not diluted is immediately fatal to human life; another would declare, "Once a poison, always a poison;" and another would ask why we should imperil our own health for the sake of the plants.

*Oxygen* was named next, among the primary resources, redundant in supply. It is a prominent constituent of all living tissues, forming seventy-two parts in a hundred of the human body with its fluids. It is taken in two conditions: first, in combination, chiefly by the plants; second, in the elemental state, by animals. In combination, it is taken by the plants from carbonic-acid gas, just noticed as a source of carbon; from water, to be considered as a source of hydrogen; and, in smaller quantities, from a considerable number of other substances. The greater part of the oxygen in animal tissues is obtained in the products elaborated by the plants.

But for all animal life the most imperative demand is for oxygen in the elemental state.

The other elemental resources are available only in their compounds; oxygen does its best service when alone. The others serve life as materials for its bodily tissues; oxygen has an additional duty, the maintenance of operations giving warmth and strength. The activities of life consume various materials, but most constantly of all they demand a raw material of inorganic nature, a simple material in its primitive condition. This supply of *elemental oxygen*, a necessity for all animal life, is a necessity that is imminent in direct proportion to vital activity, and for man is absolutely imperative. When supplied with oxygen, we can subsist days without other food; when deprived of oxygen, life fails in a few minutes. It is scarcely a figure of speech to say that the breath is the life. The energy of oxygenation is told in every stroke of the heart. The food that is eaten does not raise an iota of bodily strength without the help of the pound and a quarter of pure oxygen that is daily inhaled. To breathe poorly is to faint; to eat richly and breathe poorly is to suffocate and perish.

The *supply* of elemental oxygen is certainly impartial and bountiful without reservation. It is more than given—it is pressed upon us; to escape from it is a work of toil and difficulty. No one is poor from want of it, or rich from gain of it. Were it furnished for pay, all that a man hath would he give for an hour's supply of it. The poor, taken together, fare best in its use; while the wealthy, in their elabo-

rate contrivances to exclude the cold and wet and wind and glare of the weather, can make but slight impediments to its distribution.

One other element we were to inquire of, among the redundant materials: the unit of chemical measures, *hydrogen*. As light as it is, it makes over nine weights in a hundred of the body of man. It is obtained chiefly by the plants; mostly from water, but to some extent from ammonia, the latter being more notable as a source of another element.

Water is not quite always as free as air—failing the needs of the stationary bodies of plants more often than it does the wants of animals, and in the quantities taken as food by man hardly liable to a notable value in exchange. As a substance not wholly gaseous, it is not easy to conceive how water could be more abundantly supplied than it is, without being a burden and a hinderance to life. It is doubtful whether mankind would vote for any uniform increase in the quantity of water on the planet. If water was supplied in vapor more abundantly than it is, by having a lower vaporizing-point, the conditions of all life would be changed—the atmosphere would be put out of its adjustment with the organic creations.

Some of the simpler forms of life subsist almost wholly upon the three elemental materials we have had in consideration, with a few others of the plentiful resources; and living beings taken together use much larger quantities of these than of the substances more sparingly supplied. But, as to the relative importance of the two classes of resources, it can only be said that the higher forms of life can no more exist without the one than without the other.

Of the adequate resources, *nitrogen* is needed by the largest number of living bodies and used in the largest quantities. It enters into most animal tissues and the more complex of the vegetable products; being two and a half parts in a hundred of the body of man, or eight per cent. of its solids. It is obtained for the organic world solely by the plants, and obtained only from combinations of nitrogen, the ammonia and nitrates of the air and the soil.

The *supply* of this combined or available nitrogen in the air is limited—enough for a measure of vegetation, but not near enough for the greatest growth of food-plants and grains. The quantity of combined nitrogen carried by the rain from the air to the plant-roots was found to be, in the rainfall of a year in Great Britain, equal to seven pounds of ammonia on an acre; another year it equaled nine and a half pounds per acre. The constituents of wheat are such that twenty-four bushels require the nitrogen of forty-five pounds of ammonia; that is, for the crop on a given surface, about five times as much as the rain furnishes. Plants doubtless gather directly from the nitrogen compounds of the air without help of the rain, and obtain a larger supply from the organic mould of good soils; but that all these sources together provide hardly enough is pretty clearly

proved by feeding the roots of the plant with additional nitrogen compounds. On all but the richest soils, the suitable application of ammonia or nitrates causes a notable increase in the quantity of food-plants, and also causes an increased proportion of the nitrogenous constituents of plants. If nitrogen compounds could be laid down cheaply enough, it would augment the supplies of food and raiment, and the comfort of man, in no small degree.

Right here it comes to mind that uncombined nitrogen forms over three-fourths of the weight of the air—a provision of about eleven pounds on every horizontal square inch—and a question rises, "Why cannot the vital forces take hold on the pure element and use freely from its most lavish supply?" Well, because the universe exists. The stomach does not digest the carbon of charcoal; nor do the lungs take oxygen from water. To propose any alteration in the character of one of the sixty-three elements is to undertake the reconstruction of the universe. It is the character of nitrogen to refuse chemical combinations. Uncombined nitrogen is nowhere available for vital uses, to any appreciable extent. Filling perfectly its humble service in Nature as a diluent in the air, its qualification is to be inert and to remain changeless. Among the resources of life and in the marts of subsistence where its compounds rank high in value, nitrogen as a simple has no place at all.

This barrier between nitrogen and its compounds seems to hold firm from age to age. Out of the ocean of atmospheric nitrogen the plant selects the scattering molecules of nitrogen compounds and elaborates therefrom many nitrogenous substances. The animal elaborates some of these into other compounds. But in the final decay of products and tissues, and food not assimilated, the nitrogen of all returns again to ammonia—again in the aërial ocean, and again the resource of plants. If ammonia is oxidized in the air to nitric acid, the latter is deoxidized in the soil to nitrous acid and then to ammonia. All these compounds are very frail, and change most constantly, but together they hold the little stock of united nitrogen, losing little of it and gaining little for it, from epoch to epoch.

There are leakages, to and fro through this remarkable barrier, it is true, but they are so small that little is known of them, except that they show the strength of the barrier that limits them. On the one side, there is a little loss, by the liberation of traces of nitrogen in certain organic decompositions. Also, the explosive agents used by man in warfare and the arts result in the liberation of nitrogen—an expenditure of life-resources. On the other side, by the electrical disturbances of the atmosphere, traces of nitrogen are brought into union. The roll of thunder indicates the restoration of a modicum of that good material which was wasted for the roll of artillery. Again, it is believed that in organic decay under restricted conditions some measure of nitrogen is brought into union with nascent hydrogen.

Chemical art has not done anything toward the appropriation of this obstinate element. Nothing nitrogenous can be made of nitrogen. The manufacturers depend on gatherings from the sparingly distributed nitrates of the earth. As machinists have dreamed of perpetual motion, sleeping chemists may dream of an invention to bring atmospheric nitrogen into use, that all the barren places may be made fertile, and the whole earth flourish as a garden of fatness. But for this dream to realize the proportions of a fair probability it is quite essential that chemistry should be well asleep.

The chief commodities bearing nitrogen are nitre or saltpetre (potassium or sodium nitrate), and ammonia. In Hindostan, the rich soil-mould, warm and alkaline, becomes thinly crusted with nitrate, which is gathered and brought to market as East India nitre. Gunpowder, gun-cotton, and nitro-glycerine, as well as chemical products, are made with it. In the War of 1812, America was thrown upon her own sources for gunpowder-material, and enough nitre was found in the cave-deposits of the Southwestern States. Then France was hemmed in by hostile armies, and had neither nitre nor cave-deposits, but it was after the work of "Lavoisier of immortal memory," and the government put trust in chemistry. Berthollet and the rest soon justified the trust in the perfection of the "nitre-plantations"—beds of farm-refuse with wood-ashes exposed to the air.

These products, soil-nitre and compost-nitre, and the ammonia obtained as a by-product in the manufacture of illuminating gas, serve their several purposes in the arts and applications of man, but their limited quantities do not warrant their addition to the soil for the increased growth of food. Now, unlike these common supplies, the earth possesses a special resource for nitrogen in combination, anomalous in being fully mineralized and remarkable in being both concentrated and extensive, a chain of mines full of nitre. On the Pacific coast of South America, extending from the fourth to the fortieth degree of south latitude, about 2,400 miles along the slope of the Andes to the sea, in Bolivia, Peru, and part of Chili, there has been found a line of deposits of sodium nitrate, the "Peruvian nitre." The beds are of variable thickness, covered by one to ten yards' depth of earth and half-formed sandstone. The dry soil of the most of this rainless country is pervaded, in some degree, with this deposit. The mummied remains of the old Peruvian people are embalmed with it by the earth in which they were buried; and its crystals glisten on those ghastly relicts which were presented in the Peruvian department of the Centennial Exhibition, and those brought to this country by Dr. Steere. It has been estimated that in the province of Tarapaca, within fifty square leagues, the quantity of the nitre is not less than 63,000,000 tons. The appropriation of this vast resource has been taken up rather slowly, but has much increased for ten or twelve years past. Vessels laden with it go to the coasts of manu-

facturing countries. At Glasgow the works devoted to the production of ordinary saltpetre from the nitre of Peru extend over acres of ground. In 1868, 100,000,000 pounds were used in Great Britain. As yet, it has been applied to the nourishment of crops only to a limited extent. But this seems to be its chief destination, and for this use it lies in the earth, a vast mine of wealth, for the disposal of coming generations. When multiplied population puts the sustaining power of the earth really to the test, this fund of sustenance on the Peruvian coast must come to outweigh in value the gold and silver mines of the Californian coast.

Of the several nitrogen compounds which nourish plants, ammonia yields the most immediately satisfactory results. And, of this fertilizing material, some wellnigh mineralized deposits must be counted in with the earth's possessions. To take note of these ammoniacal materials, we have again to begin at Peru. Standing on the shores which front the nitre-beds, and looking westward upon the Pacific, there are seen, as we are told, the low patches of the Cincha Islands —islands which shine with the whiteness of a powdery covering, a loose deposit of considerable depth. A cargo of this substance was first taken to London in 1840, stored and advertised for sale, and after a while thrown into the Thames. A second cargo was tried as a fertilizer by an English farmer, and found to give such marvelous results that the shipping company made good haste to contract with the Peruvian Government for the entire deposit. This article, well known as guano, has held a settled value ever since its introduction, and, had it come into the hands of the alchemists, it would, very likely, have been presented as an elixir of vegetable life. Now, its worth is graded by analysis, and is indicated chiefly by the proportion of ammonia it contains.

The absence of rain will account, perhaps correctly, for the unusual retention of the soluble material characteristic of the guano of Peru; but the *formation of the nitre-beds* of that region is a problem in geological chemistry more difficult to determine. There are evidences of volcanic overflow and of marine deposition, and the alkali in the compound may have originated in either of these or other sources, but neither the volcano nor the sea could furnish the nitrogen of the compound. If not from organic accumulations, we seem to be referred to the air as the source of nitrogen, and left to conjecture the conditions and forces which could bring elemental nitrogen into union in so great a quantity. Without pursuing these inquiries, it may be permitted to cite a fact which seems entitled to consideration in the case, namely, the conditions for an unusual overflow of atmospheric ammonia in this region. It is fed by perpetual trade-winds—winds coming from the southeast across a wide continent of soil that is rich to rankness, and warmed under a vertical sun. Coming from the Atlantic and saturated with water, these winds gather the exhalations

of a continent, and then, shedding their water on the Andes, leave their ammonia (it may be supposed) to find its way by some means to the valleys of the western slope.

Again, these same mountain-valleys of Peru may claim to have given the world still another token of unexampled sources of nourishment, in the growth of the *cinchona-tree*, bearing the richest stock of nitrogenous bases in the vegetable world. It seems, indeed, more than a coincidence that this narrow, rainless, wind-nurtured slope of land should send to all the earth three such eminent resources as Peruvian nitre, Peruvian guano, and Peruvian bark.

Another of the materials adequate for no more than the needs of life is *phosphorus*. This element so far differs from nitrogen that it is not found uncombined in Nature, and if separated by art it immediately enters into combination on exposure to the air. It occurs chiefly as phosphate of lime, taken from the mineral kingdom by plants and also by animals. The hard part of bone is about nine-tenths phosphate, and phosphorus is an element of molecules organized into muscle and nerve.

The proportion of phosphates in the crust of the earth below organic remains is very slight, insufficient for the support of the higher forms of vegetable or animal life. It has been concentrated and gathered into the soil by the selective agency of the organic world, as it continues to be concentrated from the soil by each individual plant, and from vegetable products by each individual animal. Nearly all the phosphorus accessible on the planet has been a constituent of living bodies. Its proportion in the soil is a main factor in the growth of cereal grains. Already, and with the stretch of land to the westward, bone-earth and phosphatic guanos are well known in American markets. When phosphates fail at the root of the plant, grain fails at the mill; and when, from waste at the mill, phosphates fail in the bread, the bones and the teeth fail in growing bodies. The improvidence that leaves excretory phosphates to be washed away to the salt sea, farther from the reach of life than they were in the primitive rocks, is an improvidence that prepares an inheritance of poverty for after-generations. And the ruthlessness that permits the purveyors of food to sift phosphates from the food of men does its part to enfeeble the present generation.

There remains to notice another representative of the adequate resources, *potassium*. The statements made as to the supply of phosphorus, with some reservation, become true for potassium. Certain of the rocks contain a proportion of it, but from insolubility this is slowly available, and is insufficient for the needs of higher organic life. The soils contain more, because the organic world has gleaned for the soil. Potassa and soda are two alkalies which replace each other in the laboratory at the convenience of the chemist, but, in the choosing of the living cell, one of these is always taken and the other left.

We get potassa free from soda in the ash of a tree which grew in a soil having more soda than potassa. From sea-water, containing near 200 parts of soda to one of potassa, the sea-weeds furnish an ash having two to twenty times more potassa than soda. From the blood of man, having ten to fifteen times more soda than potassa, the muscles obtain a composition of six or seven times more potassa than soda.

This gleaning is good proof of the value of more, and the evidence is confirmed by the application of potassa as a fertilizer. The stock of potassa—which is used somewhat in the arts—is derived mainly from the gatherings of the organic world. The ash-wagon takes up the savings of the hearth. In France the washings of sheep's-wool are saved, and 160 pounds of good potassium carbonate are obtained from a ton of the wool. In the pioneer life of this country, the housewives have burned corn-cobs and taken the ash for baking-powder, eighty per cent. potassium carbonate, and preferable to the "dietetic saleratus" now used. Should the ash of the entire corn-crops of the United States be taken without loss, it is estimated that over 100,000,000 pounds of potassium carbonate would be obtained. In the salt-beds of Stassfurt, Germany, there is a good proportion of potassa, and the use of this supply has been steadily increasing, both as material in manufactures and as a fertilizer.

At the present time, the market value of the resources of life engages little general attention. There is a narrow branch of commerce, wherein the prices-current of the three elemental materials which we have taken as "adequate resources" are the values constantly under calculation in daily business. In this guild, one sells nitrogen at thirty cents, another offers phosphoric acid at five cents; and all parties have a tacit understanding that the values of nitrogen, phosphoric acid, and potassa, are to each other about as six, one and a half, and one, and that these are the only values to be considered. The technical terms of any profession or pursuit are jargon to the general ear. But hearing a man say that he "sold a hundred tons of rectified Peruvian at thirty-one cents for nitrogen, this morning," it is not so much as understood in what sort of business such jargon belongs.

Thinking of the multiplication of life and the waste of its resources, it seems that, in the time coming, the phrases that tell the rise and fall of value in commercial fertilizers may find some general recognition—may even have as much meaning for everybody as the terms of the gold-market and the silver-stocks.

It is only about a hundred years since man began to attain such definite knowledge of the components of matter as enables him to trace (we by no means say to understand) the transmutations of earth and air into tissues fit for life. Thirty-six years ago, Liebig commenced giving the people the first really systematic lessons upon the

material resources of life. Seeing the value of a knowledge that goes below the surface of things, in 1852 he wrote his conviction that, "ere long, a knowledge of the principal truth of chemistry will be expected in the political economist and statesman, as it already is held indispensable to the manufacturer and physician." And, seeing the meanings and the mysteries that cluster around the primary forms of matter, he wrote at another time: "It is not the mere practical utility of these truths which is of importance. Their influence upon mental culture is most beneficial; and the views acquired by knowledge of them enable the mind to trace, in the phenomena of Nature, proofs of an infinite wisdom—for the unfathomable depths of which language has no expression."

## THE ZODIACAL LIGHT.[1]

By Professor C. E. BRAME, A. M.

THE purpose of this contribution is to draw attention to a phenomenon which has received too little notice, and has been strangely neglected by astronomers, but which, in fact, if the conclusions of the author of the work under review are correct, is to the inhabitants of the earth one which emanates from a very near and remarkable cosmical body.

The third volume of "The United States Japan Expedition" records a series of observations on the zodiacal light, which were made by Rev. George Jones, A. M., chaplain in the United States Navy, from April 2, 1853, to April 22, 1855, during which time he accompanied that expedition sent out by the United States Government, under the command of Commodore M. C. Perry. It also contains the observations and theories of other astronomers, particularly those made by the celebrated Dominicus Cassini, a distinguished *savant* of the seventeenth century, attached to the Royal Observatory at Paris, who was the greatest cosmologist of that age.

The deductions of our author are—1. That the zodiacal light is emitted by a nebulous ring, with the earth for its centre; that is, there is a ring of nebulous matter around the earth; 2. That 60° is the full width of the stronger light, and 90° its full width including the diffused light; 3. That it is on both sides of the ecliptic; 4. That it may be seen in some latitudes under favorable circumstances, forming a continuous arch across the heavens; 5. That it must rotate on a com-

[1] Third volume, United States Japan Expedition. "Observations on the Zodiacal Light from April 2, 1853, to April 22, 1855; made chiefly on board the United States Steam-frigate Mississippi, during her Cruise in the Eastern Seas and her Voyage homeward; with Conclusions from the Data thus obtained." By Rev. George Jones, A. M., Chaplain, U. S. Navy.

mon centre, and seems full of commotion within itself; 6. From observations made then and afterward at Quito, in South America, that it is not entirely dependent on light reflected from the sun, but must shine partly by its own light.

These conclusions are given to the public with much diffidence, and with strong arguments to support them, based on a large accumulation of facts ascertained by the most careful observation.

Our chaplain became intensely interested in this investigation, and has recorded three hundred and twenty-eight observations on stereotyped star-charts, published with the volume. Sometimes, when unable from sickness to go upon deck, he was carried in his cot, that he might have an opportunity of noticing this intensely interesting phenomenon. As the voyage was one which circumnavigated the globe, he had a most favorable opportunity to prosecute his examination; and his recorded statement embraces a most minute and faithful account of his observations in nearly every longitude, and over a tract extending from 41° 49′ north to 53° 48′ south latitude.

After the return of the expedition he sought the earliest occasion to go to Quito, in South America, which is directly on the equator, where he saw the light extending in one continuous arch across the heavens. During his residence there he published several articles in *Silliman's Journal* on "The Zodiacal Light," which gave additional interest to the subject.

If anything since then of importance has appeared in any scientific journal on this subject, we have not met with it. Having for over twenty years considered it, and being anxious that more information and more confirmed conclusions should be arrived at concerning it, we invite the attention of the learned and observing to the consideration of this subject. We believe that there is no physical truth which stands isolated, but every new discovery in physical science opens the way for other truths and discoveries. If naturalists can spend days and weeks in examining and commenting on a new discovery in botany or zoölogy; if foreign countries are visited, forests and mountains traversed, to bring to light some hitherto unknown plant; if it is a triumph for a naturalist to discover a new species of microscopic animalcula—surely it is not time wasted to direct attention to a cosmical body so interesting as the zodiacal light.

Astronomical science is full of attractive interest to every lover of Nature. It is not astonishing that the study of the heavens is the oldest natural science. At an early period of the world's history the human eye and intellect were directed, with absorbing interest, to the azure arch above us, amid whose vast expanse orbs of grandeur are unceasingly running their wonderful courses. The stars, beaming with inextinguishable brilliancy, are known to be oceans of flames and centres of worlds, though apparently but points of light. The planets were known to the ancients to be more identified with our world than

other stellar bodies. Traversing space with inestimable velocity and performing their revolutions with unvaried regularity, they have long been known as part of our solar system. It seems strange that a cosmical body so near the earth as the zodiacal light should have received comparatively so little attention.

As many who read this article have never seen this light, it is necessary that it be described.

It is defined, in the work under review, to be "a brightness that appears in the western sky after sunset, and in the east before sunrise; following nearly or quite the line of the ecliptic in the heavens, and stretching upward to various elevations according to the season of the year." There is a slight objection to this definition, by which inexperienced observers may be led astray. It is spoken of as appearing after sunset, by which some would be led to suppose that it is visible immediately after sunset; whereas it is never to be seen until after the night has fully set in, and the sun's rays are some distance below the horizon. Its varied elevation, indeed its appearance, is also dependent upon the latitude of the observer as well as the season, so much so, that in very high latitudes it is but seldom seen to advantage. It has also been seen at almost every hour of the night, but is usually more distinctly seen in the temperate zones, when observed between dark and nine o'clock, as after that hour its light frequently becomes dim and diffuse.

"It appears to best advantage when the ecliptic makes its highest angle with the spectator's horizon, at which time, in moderate latitudes, it reaches to the zenith or beyond it, having near the horizon a striking brilliancy, and thence fading upward, mostly by imperceptible degrees, till at its vertex it can be made out only by a careful and experienced eye. As the seasons advance, when the ecliptic is declining gradually toward the horizon, the zodiacal light fades away till it is perhaps entirely lost to view, or can be seen only by those who have followed it in its changes, night after night, and are thus able, by familiar acquaintance, to detect and trace its dim markings in the sky."

Humboldt, in "The Cosmos," vol. i., remarks:

"Those who have been for many years in the zone of palms must retain a pleasing impression of the mild radiance with which the zodiacal light, shooting pyramidically upward, illumines a part of the uniform length of tropical nights. I have seen it shine with an intensity of light equal to the milky-way in Sagittarius, and that not only in the rare and dry atmosphere of the summit of the Andes, at an elevation of from 13,000 to 15,000 feet, but even on the boundless grassy plains, the llanos of Venezuela, and on the sea-shore beneath the ever-clear sky of Cumana."

Prof. Olmsted, in his "Astronomy," describes it as follows:

"Its form is that of a luminous pyramid, having its base toward the sun. It reaches to an immense distance from the sun, sometimes even beyond the orbit of the earth. It is brighter in the parts nearest the sun than in those that are more remote, and terminates in an obtuse apex, its light fading away by insen-

sible gradations until it becomes too feeble for distinct vision. Its aspects vary very much with the season of the year."

The crepuscles, or streaks of light from the sun, must not be mistaken for the zodiacal light; the former are sometimes visible between twilight and dark, the latter not until the shades of night have fully set in. Neither must the milky-way be mistaken for it by inexperienced observers, as the zodiacal light has a warm yellowish tinge unlike the cold white light of the milky-way.

Having endeavored to open the way for a consideration of the subject, we will now proceed to give a history of former observations.

There is no mention of any appearance of this light by very early writers. There is mention of Arcturus and the bands of Orion in the book of Job, and the constellations of the zodiac were assigned names at a very early date. The zodiacal belt was in use among the ancient Egyptians and Hindoos. If this light had been visible, it is highly probable some ancient writer would have spoken of it. Our author observes:

"It is scarcely probable that a phenomenon so striking in southern latitudes should have escaped the attention of early astronomers in those countries, but we meet with nothing in their works (referring to it) of a fully definite and reliable character."

He is, however, of the opinion that it may have been overlooked or mistaken for the crepuscle at early dawn or twilight.

It has been supposed that Pliny, who wrote in the first century of the Christian era, alludes to it under the name of *trabes* or the *δοκους* of the Greeks, but Humboldt thinks that Pliny refers to another matter.

Ammonius, in his life of Charlemagne, A. D. 807, mentions an appearance somewhat like the zodiacal light, but there was no reliable notice of it before it was described in Childrey's "Britannia Baconica" in 1661, which gives a brief description of its appearance and shape. The reference to it may be found in that work, at page 183.

It was reserved for Cassini to direct attention to its examination for the first time with earnest inquiry and interest. His first notice of it was on the evening of the 18th of March, 1683. He was watching in the west for other things, but was struck with the appearance of this luminous streak reaching far up in the sky. Like most discoverers, Cassini immediately formed a theory in regard to it after making but ten observations. This hypothesis, based on very insufficient data, has continued to the present time to influence the opinions of astronomers, and has retarded interest in observing its phenomena. Like most theories of the heavenly bodies in their first origin, it was doubtless erroneous, and, like the Ptolemaic theory of the solar system, it has materially interfered with the establishment of a correct knowledge of what is the truth.

Cassini discovered very soon that as time advanced through March and April, the upper or northern edge of this light inclined more and more from the ecliptic, and stretched farther to the northward; and knowing that the sun's equator, as shown by his spots, was also then stretching off from the ecliptic in a similar way, he came to the conclusion that the substance giving this light was closely connected with the sun's equator, and was consequently changing its position with regard to that equator.

He argued, further, that as the sun has an atmosphere, and is therefore capable of emitting dense vapors, and is continually sending out matter of exceeding fineness which we call light, consequently this luminary might also, by its motion on its axis, send out a substance intermediate in character between the two; which substance, either self-luminous or by reflection, might give us the zodiacal light. To support this theory, he gives to this body a lenticular shape, about twice the thickness of the sun as seen in March, but only of the sun's thickness when seen in June. Whether he meant to have this lenticular-shaped medium to be attached to the sun, and revolving with it at the same time, is not apparent. He devoted a part of his time for about eleven years, in a very desultory manner, to observing this light.

Cassini's labors led other observers to direct their attention to the zodiacal light. Fabio de Duillier, who was his colleague for a while at Paris, is worthy of particular notice, as having conceived the idea that it consisted of particles of matter distinct from the sun, and arranged in shape like a solid zodiac; which body of uneven surfaces, and rotating round the sun, he supposed, gave us the zodiacal light.

In 1731 Mairan gave considerable attention to this subject in a work on "The Aurora Borealis." He advanced the theory that this light is reflected from the sun's atmosphere, stretched out into a flattened spheroid or lenticular-shaped body, revolving with the sun—an idea which Laplace has forever set at rest by demonstrating that the sun's atmosphere can extend no farther than to the orbit of a planet whose periodical revolution is performed in the same time as the sun's rotary motion about its axis, or in twenty-five days and a half; that is, only so far as nine-twentieths of Mercury's distance from the sun.

Since the time of Mairan, until 1853, but little attention appears to have been given to this subject. In 1833, however, Biot, in order to account for the meteor-shower of that year, attempted to show that the shower was owing to the earth's passing at that time near the node of the zodiacal light. But calculations were made by J. C. Housseau in order to see whether the nodes of the sun and the zodiacal light do actually correspond. After careful observations and calculations, in which he was assisted by nine diligent observers, Housseau thinks he has shown that these nodes are different, and that

therefore "the supposition of the existence of this light in the plane of the sun's equator does not satisfy the observations made." The closing sentence of his very interesting article gives the first intimation that the zodiacal light has a near connection with our globe. Housseau says:

"One is struck, without doubt, with the near approach, which our elements show, between the line of nodes of the zodiacal light and that of the nodes of the terrestrial equator upon the ecliptic. This circumstance, as far as it is verified, may help to explain the causes of this luminous phenomenon—causes which are, it may be, more local than has hitherto been supposed."

This notice is the only one, of any importance whatever, that was taken of the zodiacal light for many years, with the exception of some experiments made to ascertain whether there is any heat connected with it—experiments which we think resulted in establishing the fact that it is near enough to emit heat sufficient to affect a thermo-electric pile of twenty-five pairs, causing the needle of the galvanometer to indicate 12° when the pile was directed toward the base of the zodiacal light.

We come now to a consideration of the observations taken during the cruise of the Japan Expedition, and we hope our readers are not weary of the subject; for, if it can be demonstrated that we have a ring of nebulous matter around our globe at a distance of 150,000 to 200,000 miles, there are many inquiries growing out of that fact full of interest, and yet to be answered by experiment and induction. It will be a matter, then, to be considered whether it is self-luminous—that is, of the nature of the sun's photosphere—or whether it shines only by reflected light, like the rings of Saturn; whether it is increasing or diminishing in magnitude and extent. If it is shown to be self-luminous, we will then wish to know whether it may not be widening and extending itself, at the same time increasing in its capacity to emit both light and heat, until it envelops the entire globe, modifies climate, melts the icebergs and snows of northern latitudes, and dispels darkness from our globe. We may inquire, too, whether it may not be used as a grand instrument in the hands of the Creator for the future development of his purposes in regard to our globe. It may also be an inquiry whether it does not already influence the magnetic state of the earth, and play an important part in the causes producing the aurora borealis. These and many more similar questions will arise from the establishment of the fact that the zodiacal light emanates from a ring of nebulous matter so near our earth. Let us, then, give our author a close examination and a patient hearing, that we may be enabled to form a correct judgment as to the truth of his deductions.

We have not space to present all the reasoning by which our author shows that the zodiacal light cannot be produced by a ring of nebu-

lous matter revolving round the sun, either within or beyond the orbit of the earth.

He starts with the proposition that such a ring must be either—1. Within the earth's orbit; 2. Surrounding the earth; or, 3. Without the orbit of the earth.

It cannot be *within* the earth's orbit; if so, we could never have it at any great altitude at any period of the night, and we could never have the zodiacal light at midnight on both horizons simultaneously.

We omit the diagram constructed for the consideration of the theory which supposes this ring to be around the sun and *beyond the orbit of the earth*, by which he shows that this supposition will not account for the lateral changes observed in the zodiacal light. He says:

"The query arises, 'Can such lateral changes, so uniformly observed, as the evening or morning advances, agree at all with the idea of a nebulous ring giving us this light at a distance from the spectator of 160,000,000 or 180,000,000 miles?' A ring of the character supposed, it seems to me, could give us a zodiacal light only of one uniform shape, namely, with the opposite borders receding from each other for a short distance from the apex, and then running parallel, one to the other, the whole way down to the base. Nor could the hourly changes of time produce any other changes in these boundaries than a rising or sinking of the apex of the light; the boundaries, say at nine o'clock P. M., extending a little higher in the sky than at eight, and so continued, with a parallelism of the opposite sides, down to the horizon. How different this from the true facts of the case!

"The evident and most decided connection between these boundary-lines and the spectator's place, as regards the ecliptic, is also a matter of the greatest significance in drawing our conclusions in regard to the origin of this light. Now, supposing the base of the zodiacal light to be at a distance of 200,000,000 miles, how is it possible that the fact that the spectator is a short distance north or south of the ecliptic can govern the reflection from the nebulous ring at that immense distance, and place it on his side of the ecliptic? If he is on the north side of the ecliptic, not only is the main body of the light down to its base on that side, but the lateral changes of the boundaries, as the hours pass, are altogether or chiefly on that side; and so equally with the south. If he is on the ecliptic or near it, the zodiacal light stretches equally, or nearly so, on each side of that line. Also, if he changes rapidly during the night to or from the ecliptic (as was the case on shipboard) the boundaries of this light also change, being regulated by his motion (from one place to another). That the apex of the zodiacal light, from such a ring around the sun, might be so affected by the spectator's position is not unreasonable, but that the boundary-lines should be so affected seems to be utterly inadmissible.

"It is worthy of remark, also, how even and uniform, from apex to base, the change in the boundary-lines is as the hours change; as if the substance giving the zodiacal light were not only near, but also at one uniform distance from the spectator; the portions of it at the apex and base of the light all equally affected by his changes on the earth."

He shows by Bouguer's law of reflected light that the zodiacal light, if from a ring of nebulous matter beyond the earth's orbit,

would emit a light of the same intensity the whole way from the base to the apex. But another law of optics, that the strength of light is inversely as the squares of the distances of the object affording the light, would here make its application; and this ring, at our zenith, being by that supposition about 140,000,000 miles nearer to us than at the base, we should then have the zodiacal light far more intense at the apex than at the base; all of which is entirely opposite to the facts of the case.

He offers, now, as a last conclusion, *the hypothesis of a nebulous ring with the earth for a centre.* He makes certain deductions from the examination of the preceding theories.

"They are—1. That the substance giving us the zodiacal light must be *equally near* to us in all its parts, inasmuch as the lateral changes of the light, i. e., the changes of boundaries, have a uniform character and mostly a parallelism in their whole extent from apex to base; 2. That no part of this substance can be very remote from us, inasmuch as the outlines of the light were clearly and sensibly affected by my own position on the globe, and even by my change of position in a single night; and, 3. That the laws of reflected light require an arrangement or a shape of this nebulous matter which will give us, at the base of the zodiacal light, larger angles between the lines of the incident and reflected light than at other portions, and also a regular decrease of such angles from the base to the apex of the light, as produced by such a shape. These three requirements appear to be fully met by an hypothesis which, if the theories examined are untenable, is now the only one remaining to us.

"The hypothesis is that the zodiacal light is *a ring around the earth.*

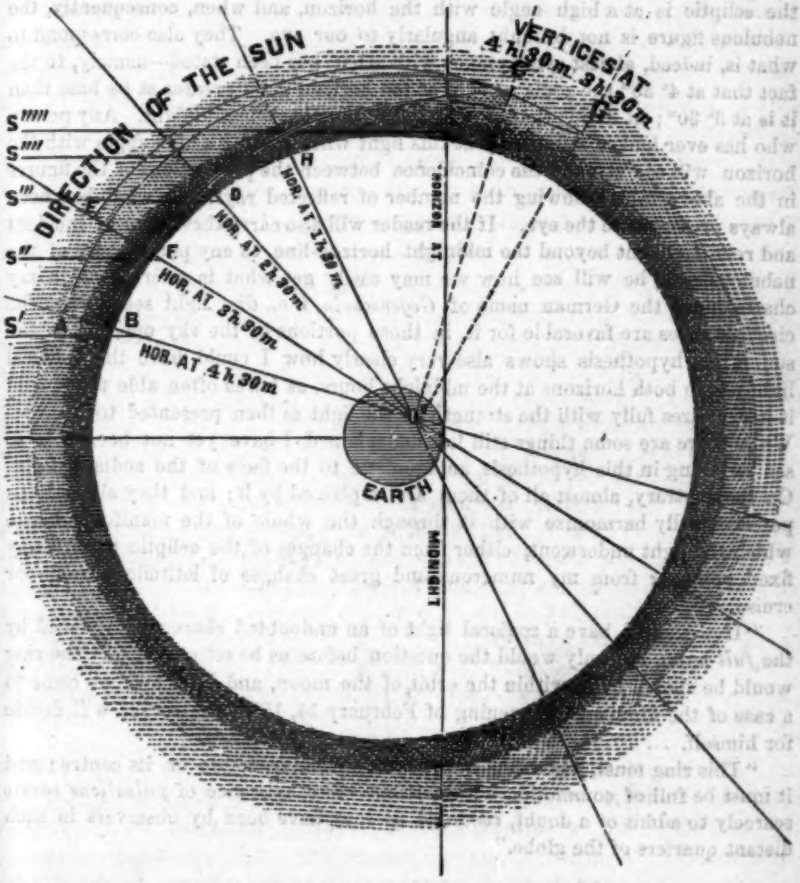
"The thought is a somewhat startling one, yet startling only from its novelty; for it is entirely in accordance with what we know of our sister planet (Saturn), and also with the whole of Laplace's celebrated theory of the formation of globes."

We will not take up time and space with quoting his application of that theory in explaining some of the phenomena of this light.

Avoiding the consideration of these topics, we will proceed to apply the result of Bouguer's experiments on reflected light to this case.

In the annexed diagram he takes an observation made on the 4th of September, 1854, as an example, for the reason that it is a simple one, and one also in which the spectator is near the plane of the ecliptic. It was made in latitude 22° 18′ north, longitude 114° 10′ east. The sun rose at $5^h\ 48^m$. The stronger light was at $3^h\ 30^m$ to $4^h\ 30^m$, the diffuse light at $3^h\ 45^m$. Sun's longitude 161° 35′. The horizons at $4^h\ 30^m$, $3^h\ 30^m$, $2^h\ 30^m$, and $1^h\ 30^m$, and at midnight, are given, together with the line of the spectator's vertices, as well as his positions O, o, etc., at $4^h\ 30^m$ and $3^h\ 30^m$. A, B, C, F, are the boundaries of the zodiacal light at $4^h\ 30^m$, and E, F, G, at $3^h\ 30^m$; the apices C and G are carried a little above the more condensed portions of the ring; but the reader is at liberty to suppose them to be at any other part, as he may think best. The direction of the sun is given; and S′, S″, S‴, S⁗, S⁗′, are supposed to be rays of light proceeding from that luminary.

In this diagram, the sun's rays being S′, S″, etc., BO, FO, etc., will be the reflected rays; and the several angles between these lines of incidence and reflection, together with the number of rays reflected




NEBULOUS RING, WITH THE EARTH FOR ITS CENTRE.

[The relative proportions of the earth and the ring, and also its distance, are of course not given in this diagram with any effort at certainty; the upward extent of the ring is probably far greater than can be here represented. The diagram is, however, sufficiently correct for our present purposes of elucidation.]

to the eye, out of every 1,000 incident rays, according to Bouguer, are in the following table:

| | ANGLE. | Rays reflected from Smooth Water. | Rays reflected from Plate-glass not quick-silvered. |
|---|---|---|---|
| S′, BO | 161° | 343 | 422 |
| S″, FO | 146° | 184 | 270 |
| S‴, DO | 131° | 101 | 162 |
| S⁗, HO | 116° | 59 | 105 |
| S⁗′, at midnight | 90° | 18 | 25 |
| S⁗′, CO | 67° | 18 | 25 |

"We find in the above table a strong argument for such a ring around the earth. The figures, taking either of the two columns, for water or for glass, correspond in a very striking degree with the varying intensity of the zodiacal light from the base upward, as we have it on any clear morning or evening when the ecliptic is at a high angle with the horizon, and when, consequently, the nebulous figure is not brought angularly to our eye. They also correspond to what is, indeed, almost synonymous with what has been stated—namely, to the fact that at $4^h\ 30^m$ the zodiacal light at the horizon is far greater at its base than it is at $3^h\ 30^m$; at $3^h\ 30^m$ than it is at $2^h\ 30^m$, etc., back to midnight. Any person who has ever looked attentively at this light when making a high angle with the horizon will see at once the coincidence between the proportions of the figures in the above table, showing the number of reflected rays, and what has been always presented to the eye. If the reader will also carry these lines of incident and reflected light beyond the midnight horizon-line, to any point there of the nebulous ring, he will see how we may easily get what is referred to in my charts under the German name of *Gegenschein*, i. e., dim light seen, when the circumstances are favorable for it, in those portions of the sky opposed to the sun. This hypothesis shows also very clearly how I could have the zodiacal light above both horizons at the midnight hours, as I was often able to do, and it harmonizes fully with the strength of the light as then presented to the eye. While there are some things still left unexplained, I have yet not been able to see anything in this hypothesis antagonistic to the facts of the zodiacal light. On the contrary, almost all of them are explained by it; and they all, as I can perceive, fully harmonize with it through the whole of the manifold change which the light underwent, either from the changes of the ecliptic toward any fixed point, or from my numerous and great changes of latitude during our cruise.

"If we could have a zodiacal light of an undoubted character produced by the *full moon*, not only would the question before us be set at rest, but the ring would be shown to be within the orbit of the moon, and how near we came to a case of the kind on the evening of February 14, 1854, the reader will decide for himself. . . .

"This ring must, according to the laws of matter, rotate on its centre; and it must be full of commotion within itself. The existence of *pulsations* seems scarcely to admit of a doubt, recorded as they have been by observers in such distant quarters of the globe."

In conclusion, we would say that two simultaneous observations, made in equatorial regions—for instance, one by an observer at Quito, and another by an observer on the island of Sumatra, in which both observations presented the zodiacal light stretching as an arch across the heavens from east to west—would, it seems to us, demonstrate the fact that it is a ring around the earth. Now, if observations taken in almost every space of 15° of longitude have been made and its existence demonstrated, does not that amount to about the same thing?

We leave the subject, inviting information and discussion from all who are informed in regard to this long-neglected phenomenon.

# DR. BALFOUR STEWART.

AMONG English physicists Dr. BALFOUR STEWART holds a distinguished place for the originality and extent of his experimental researches, the grasp of his subtile and comprehensive inquiries, and the boldness and freedom of many of his speculations.

He was the son of a merchant, and was born in Edinburgh, November 1, 1828. At the age of fourteen he went to the University of St. Andrews, and afterward to that of Edinburgh, from which he graduated. During his college course he paid a great deal of attention to pure mathematics, and is credited with having rediscovered, independently of books, La Grange's method of dealing with the differential calculus. After leaving college he spent four years in a mercantile house, and was for two or three years in Australia; but his father's preference that he should be a merchant did not coincide with his own inclinations, and he at length determined to devote his life to physical science.

On his return from Australia, he was so fortunate as to secure the friendship of the late Principal Forbes, and became his assistant in Edinburgh for three years, 1856–'57–'58.

Dr. Stewart has been Director of the Magnetic Observatory at Kew, where he has made numerous and important magnetical observations in connection with the eminent physicist, Mr. Warren De la Rue. He is Professor of Physics in Owens College, Manchester, a Fellow of the Royal Society of Great Britain, of the Astronomical and Meteorological Societies of London, and of various learned bodies on the Continent and in the United States. He received the degree of LL. D. from Edinburgh University, and in 1868 the Rumford Medal of the Royal Society for his researches in light and heat.

Dr. Stewart has been a very active worker in the scientific field, and is the author of many publications, especially in the branches of meteorology, magnetism, and solar physics, of which the following are the most important:

*Papers connected with Heat and Light.*—1. An Account of Some Experiments on Radiant Heat, involving an Extension of Prevost's Theory of Exchanges (Transactions of Royal Society, Edinburgh, 1858). 2. Researches on Radiant Heat, Second Series (Transactions of Royal Society, Edinburgh, 1859). 3. On the Light radiated by Heated Bodies (Proceedings of Royal Society, London, 1860). 4. On the Nature of the Light emitted by Heated Tourmaline (Proceedings of Royal Society, London, 1860). 5. Internal Radiation in Uniaxal Crystals (Proceedings of Royal Society, London, 1861). 6. Report on the Theory of Exchanges (British Association, 1862).

*Papers connected with Meteorology, Magnetism, and Sun-spots.*

—1. On an Instrument for measuring Fluctuations of Temperature (Proceedings of Royal Society, London, 1856). 2. Reduction of Makerstown Magnetical and Meteorological Observations, from 1847 to 1855 (Transactions of Royal Society, Edinburgh, 1860). 3. On the Magnetical Survey of Scotland undertaken by the late Mr. Welsh (Report of British Association, 1859). 4. An Account of the Self-recording Magnetographs erected at the Kew Observatory by the late Mr. Welsh (Report of British Association, 1859). 5. On the Great Magnetic Disturbance, August to September, 1859 (Transactions of Royal Society, London, 1861). 6. On the Nature of the Forces concerned in producing the Greater Magnetic Disturbances (Transactions of Royal Society, London, 1862). 7. A Comparison of the Kew Curves with the Earth-Currents registered at Greenwich during the Magnetic Storm of December 14, 1862 (Proceedings of Royal Society, London, 1863). 8. On Earth-Currents during Magnetic Calms, and their Connection with Magnetic Changes (Transactions of Royal Society, Edinburgh, 1863). 9. An Account of Some Experiments with an Air-Thermometer (Transactions of Royal Society, London, 1863). 10. Results of a Comparison of Simultaneous Traces of Self-recording Magnetographs at Kew and Lisbon—in conjunction with Senhor Capello (Proceedings of Royal Society, London, 1864). 11. On the Sudden Squalls of October 30 and November 21, 1863 (Proceedings of Royal Society, London, 1863). 12. Note on the Secular Change of Magnetic Dip at the Kew Observatory (Proceedings of Royal Society, London, 1866). 13. A Description of the Self-recording Instruments of the Meteorological Committee (Report of the Meteorological Committee for 1867). 14. A Comparison between the Records of the Barographs at Oxford and Kew (Proceedings of Royal Society, London, 1867). 15. An Account of Experiments on Aneroid Barometers (Proceedings of Royal Society, London, 1868). 16. On the Laws regulating Magnetic Peaks and Hollows (Proceedings of Royal Society, London, 1869). 17. Results of a Preliminary Comparison of the Kew and Stonyhurst Declination Curves—in conjunction with the Rev. W. Sedgreaves (Proceedings of Royal Society, London, 1869). 18. Remarks on Meteorological Reductions (British Association, 1869). 19. Results of Observations of Dip and Horizontal Force made at Kew from April, 1863, to April, 1869 (Proceedings of Royal Society, London, 1870). 20. On the Variations of the Daily Range of Atmospheric Temperature as recorded at the Kew Observatory (Proceedings of Royal Society, London, February, 1877). In this paper the author shows that in the daily range of temperature there is unmistakable reference to the moon. 21. On the Variations of the Daily Range of Magnetic Declination, as recorded at the Kew Observatory (Proceedings of Royal Society, London, 1877). In this paper Prof. Stewart establishes the opinions previously held by Mr. De la Rue, Mr. Loewy, and himself, clearly showing that in the variations of declination range at Kew

there are inequalities having reference to planetary configurations. He also shows that there is a great likeness between meteorological and magnetical phenomena, and suggests that a further study of sun-spots may ultimately enable us to predict longer and longer meteorological occurrences.

*Papers on the Heating of a Disk by Rapid Rotation in Vacuo.*—1. On the Heating of a Disk by Rotation in Vacuo—in conjunction with Prof. Tait (Proceedings of Royal Society, London, 1865). 2. On the same subject—in conjunction with Prof. Tait (Proceedings of Royal Society, London, 1866). 3. On the same subject—in conjunction with Prof. Tait (Proceedings of Royal Society, London, 1873). 4. (A Possible Explanation of its Effect?) On the Temperature Equilibrium of an Inclosure containing a Body in Visible Motion (Literary and Philosophical Society, Manchester, November, 1870). Dr. Stewart endeavors to explain the heating of a disk of rotation *in vacuo* by an extension of the theory of exchanges.

*Papers on Solar Physics by Messrs. Warren De la Rue, B. Stewart, and B. Loewy* (Preliminary Researches—printed for private circulation by Mr. De la Rue).—*First Series:* On the Nature of Sun-spots (1865). *Second Series:* Area Measurements of Carrington Observatory, and Deductions therefrom (1866). *Third Series:* On the Distribution of Spots in Heliographic Latitude.

*Kew Researches.*—1. Heliographic Positions and Areas of Sun-spots observed with the Photoheliograph during the Years 1862 and 1863 (Transactions of Royal Society, London, 1869). 2. Positions and Areas of Sun-spots observed at Kew during the Three Years 1864–'66, as well as Fortnightly Values of Spotted Solar Area from 1832 to 1868 (Transactions of Royal Society, London, 1870). 3. On Some Recent Researches in Solar Physics, and a Law regulating the Time of Duration of the Sun-spot Period (Proceedings of Royal Society, London, 1871). 4. Further Investigations on Planetary Influence upon Solar Activity (Proceedings of Royal Society, London, 1872). 5. On a Tendency observed in Sun-spots to change alternately from the one Solar Hemisphere to the other (Proceedings of Royal Society, London, 1873).

Besides various miscellaneous papers, not mentioned here, Dr. Stewart is the author of the following works:

An Elementary Treatise on Heat; Lessons in Elementary Physics; Conservation of Energy ("International Scientific Series"); and The Unseen Universe (in conjunction with Prof. Tait).

# CORRESPONDENCE.

## MIND-READING BY THE EAR.

*To the Editor of the Popular Science Monthly.*

SINCE the publication of my article on "Physiology of Mind-Reading," in the February number of your MONTHLY, I have received the following, which, as presenting a new phase of the subject, is of much interest.

There are three general methods of mind-reading—by the touch, by the eye, and by the ear. My article was devoted only to the method and modifications of the method introduced by Brown—by the touch. Mind-reading by the eye—that is, watching the movements and changes of the features, or of the hand or fingers—is done every day by all of us, and is frequently utilized with great success by mediums. Mind-reading by the *ear*, as described in the first experiment noted in the following letter, is not so well known. The author of the letter, who does not wish to have his name used, is also an expert in the art of mind-reading by the eye or by the touch.

The general physiological principle is the same in all these methods of mind-reading—namely, the detecting by the operator, through some one of the senses, of the unconscious muscular or bodily movements of the subject, through mind acting on body. GEORGE M. BEARD, M. D.

*Dr. George M. Beard—*

DEAR SIR: I was much interested in your article on the "Physiology of Mind-Reading," as I have paid more or less attention to the subject, in an amateur way, for eight or ten years past, and I think that I can give you some new "developments."

While your theory is undoubtedly correct, you describe certain conditions as "essential" which I have found by frequent successful practice to be unnecessary. Thus you say that the connection between the subject or subjects must be such "as easily to allow the sense of muscular tension to be communicated." The operator or medium "must be in physical connection with the subject." Again, "where the connection of the operator with the subject is made by a wire, so arranged that mass-motion cannot be communicated, . . . the operator does just what he would do by pure chance and no more." In reply to this, I would say that I am in the habit of repeating Brown's tricks of finding hidden objects, designating persons and things thought of, etc., without any physical contact whatever, while I am blindfolded, precisely as Brown was in his public performances.

The only condition I require of the subject is, that he shall follow me at a distance of about three or four feet, as I grope my way *apparently* at random, keeping his mind fixed upon the object. I am able to tell, by close attention, when he follows me readily, and when reluctantly; in this way I cautiously map out the *direction* in which he tends to follow me most readily. When I approach the vicinity of the object thought of, he shows no inclination to move in any one direction. There is, of course, a certain element of uncertainty in the finding of a small object under these circumstances, but the proportion of failures is astonishingly small. I reached this result by a succession of experiments, first through a rigid rod, then through a wire, then a stretched string, then a string with a loop. I then worked without contact *not* blindfolded. I would walk backward, holding out my right forefinger, and directing the "subject" to hold his right forefinger, at a distance of six inches (this would convey to most people the impression of two terminal poles of a battery or electrical machine), and he would often have an imaginary pricking, as of sparks at the finger-tip. I would then proceed around the room, and when moving in the right direction the hiatus would be rapidly closed between the two fingers.

I can almost invariably distinguish an intentional or accidental indication from an involuntary one, and I do not find that keeping the "arm perfectly stiff" interferes very seriously. The indications are not confined to muscular contractions or relaxations of the arm, but it is a sympathetic movement of the whole body.

It is a curious fact that subjects who naturally work well will be very slightly influenced by the explanation of the apparent mystery. You may assure them that every *correct* movement you make is only a translation of their own, and they will declare positively that they are trying to move in the *opposite* direction, and, in fact, they often do hold back with their feet, while giving the most positive indications with their arms.

I have found that a large majority of well-educated people have an innate bias for mysteries, and prefer to refer these "phenomena" to animal magnetism, auras, psychic or odic force, or any incompre-

hensible cause, rather than to the rational explanation of unconscious movement. Some time since, I had a curious illustration of this fact, and at the same time an admirable proof of the physical theory (if any were required), in an experiment suggested by a gentleman of this city. I had concluded a successful exhibition at an evening company, and described the precise method by which the experiments had been performed. This gentleman said to me privately that he could suggest an experiment which, if successful, would disprove my theory of muscular or physical movement. I retired from the room, and was brought in blindfolded. Meanwhile he had requested a very good subject with whom I had done a number of complicated things to hide an article. The gentleman then took the towel from *my* head and blindfolded the "subject"—turned him rapidly round several times, and told him to think of the object. He said, "Now you will find it by mental communication only." I started off rapidly, but, of course, received no indications. I then purposely touched his hand to the mantel-piece in the back-parlor. Instantly he unconsciously calculated the position of the hidden article and directed (not led, for I always go in advance of the "subject") me toward the front-room; then he was lost, until I again touched his hand to some object, when I received a fresh indication. In this way I finally found a ten-cent note, rolled into a little ball, and attached to the lower knot of a cord running through the handle of a small feather-duster, which was hanging from the bell-handle on the wall. I did not, however, immediately produce it, as I wished to experiment further. I led the "subject" off to another part of the room, and he immediately brought me back to the duster. Again I led him away to the same place, and turned him round so as to confuse him. All indications ceased, even when I held his hand within an inch of the duster.

In regard to finding small objects, I have no difficulty in picking out any letter on a page of a book or newspaper, and I frequently spell out abstract thoughts or names of people, places, etc., thought of, in this way: I hold a sharp-pointed stick or pen-handle in my left hand, pointing downward, with the same hand grasping the left hand of the "subject." I thus pick out letters on the page which spell the thought in the mind of the "subject."

The power of perception of these minute indications is capable of being developed to an astonishing degree, and I have often been amazed at the curious effects produced, a few of which I have indicated to you.

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*To the Editor of the Popular Science Monthly.*

In Tyndall's discourse on "Fermentation and its Bearings on the Phenomena of Disease," as published in the December number of The Popular Science Monthly, he describes an injury he met with in falling upon some sharp rocks. He limped to his hotel, and remained quietly in bed for four or five days, and, having quite recovered, removed the bandages, and found the wound "perfectly clean, uninflamed, and entirely free from pus." This slight exposure led to inflammation, an accumulation of pus, and, finally, to an abscess several inches below the wound, and might have led to fatal results. A year after, Tyndall exposed in the same room tubes containing organic infusions, and in two days the infusions were swarming with the bacteria of putrefaction with which the dust-laden atmosphere was charged.

I have lately been reading General Hazen's interesting book entitled "The School and the Army," and in it find the following testimony regarding the treatment of wounds in in-door and out-door hospitals, which, taken in connection with Dr. Canniff's correspondence in the April number of your magazine concerning Dr. Lister's antiseptic treatment of wounds, may be of interest to your readers. General Hazen says:

"The Germans have fallen into the same error that we committed — that of using buildings for hospitals instead of tents, or field-hospitals; and there is scarcely a doubt that the French will do likewise. It is unaccountable that scientific and practical medical men do not appreciate and advocate the advantages of out-door over in-door hospitals. It is a matter of the gravest importance, and the humane societies of Christendom can in no way do more good than by thoroughly investigating and making generally known the facts relating to permanent hospitals in time of war. The seeds of disease cling to the walls, ceilings, and floors, and the death-rate of the wounded is often greatly increased by putting them in these places. So strongly was I impressed with this in our war that, as far as was in my power, I kept my wounded out of them. At the battle of Mission Ridge, the colonel of the Forty-first Ohio lost his leg above the knee by a musket-shot. I forbade his going to hospital, and caused him to be treated in his rude, split-shingle cabin, and his recovery was remarkably rapid. Officers of my command who were grazed by musket-shot upon the arms were put into the hospital, and died from gangrene. At that battle the wounded of General Thomas's army were treated in fixed hospitals, or buildings fitted up beforehand at Chattanooga, with many comforts and good care. The proportion of deaths among the wounded was frightful; and we were told that it was due to the low

vital condition of our men, resulting from short rations. The fact was, they died from hospital diseases. General Sherman's army, just arrived from Mississippi, without hospitals, treated their wounded in the field, and the proportion of recoveries was astonishingly great. They were cured by fresh air. At the battle of Peach-Tree Creek, a very worthy staff-officer of mine was seriously, although not dangerously, wounded in the abdomen. The medical rules were very strict, but, by sending messengers all night, I got authority to send him home to the North, without his going to the hospital. Arriving at Nashville, and being unable to proceed without further medical authority, he was taken charge of, and put into one of their comfortable hospitals. In a few days he became terribly afflicted with gangrene, and only escaped with his life after a perilous and racking illness."

These observations are doubtless familiar to surgeons; but if, with Tyndall's experiments, they are found to be absolutely correct, does it not become necessary to examine into the condition of the various hospitals throughout the country, and to provide at least some special conditions for the treatment of flesh-wounds — an apartment, for example, separated from the main building, which may be deluged at intervals with superheated steam to destroy the germs, or such other precaution as shall insure an atmosphere of absolute purity during the dressing of wounds?

We would commend this subject to the State Boards of Health.

EDWARD S. MORSE.

SALEM, MASSACHUSETTS, *April* 26, 1877.

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## THE NEW IDEAS ABOUT SPACE.

*To the Editor of the Popular Science Monthly.*

THE great attention now given to this subject in Europe seems to render appropriate a short communication to bring it more directly before Americans. In point of fact, the mathematicians have been making a conquering migration into the fair fields of philosophy, and instead of any longer being content to receive from Metaphysics her definitions of space, they have for themselves attacked the question by the methods furnished by two thousand years of advance in their own science. Already they have made some wonderful strides toward the solution, and the new notions are very fascinating.

It is, perhaps, daring to attempt to give an adequate idea of some of these without the use of mathematical symbols and analytic geometry; still it seems desirable for each of the special sciences to be able to express *results* in untechnical language, and we will try.

Every schoolboy knows that what is called multiplying a linear inch by a linear inch gives a square inch, and that again multiplying this square inch by a linear inch gives a cubic inch. Now, I suppose, many of the most original boys may have asked themselves, "What would be the result of multiplying this cubic inch again by a linear inch?" Up to this nineteenth century the answer has probably always been, that the thing was unthinkable and inexpressible, and that, although by analogy we see no reason for being stopped so abruptly, yet such is our invariable experience.

Now, the two men who first and independently stepped over this mental fence were the great Gauss whom Germany is now celebrating, and a Russian named Lobatchewsky. They both said that the space with which we are familiar is only one kind of space out of a number of possible spaces, each logically self-consistent; but that, from the fact of all our ages of experience being in this particular space, we cannot perfectly picture to ourselves any one of the other kinds, though they are entirely expressible in analytic geometry.

Now, it has often been remarked that in things very familiar to us we see nothing noteworthy. So we see nothing strange in our conception of a straight line and a plane, yet we may think it strange when we are told that this peculiar notion of straightness, smoothness, or flatness, is also inherent in our ideas of our space. This was discovered many years ago by Prof. Sylvester, and, to denote it, he called our space a homaloid, or a homaloidal space. To us it always has three dimensions, and no more; and, just here, all readers may be advised not to try to *picture* to themselves any higher kind of space, since they must fail as utterly as they fail to see the ultra-violet rays of the spectrum. Moreover, it has not yet been demonstrated that any other kind of space actually exists in the physical-world. This is a matter which can only be settled by physical experiments; and perhaps it is to be hoped that our old space will stand all tests, for, should it not, then all our science would have to be put on a new basis, at least in so far as related to space. So, you see, no one need be discouraged at his inability to perfectly conceive any other space than our common one. But, as the others are logically possible and mathematically true, and are necessary to get a complete knowledge of our own space, we will attempt to convey some notion of them. In our space we have length, breadth, and height, and to each of these corresponds a coördinate in analytic geometry. This is why we call ours a space of three dimensions, and we cannot picture any other dimension. But we find analytic geometry just as ready to deal with a space which

should be like ours in every other way, but should have another or fourth dimension; and this led to the question, "May not our space have a fourth dimension?"

Now, our only way of reasoning about the matter is to take analogous cases in the picturable spaces of two dimensions, and carry the analogies up from two to three, from three to four dimensions.

Let us take the easiest illustration. Suppose beings not living *on* the *surface* of a sphere, but *in* the *surface* of a sphere, and so having no conception of the third dimension of space.

Now, if they were so small as only to perceive a small portion of their surface, they might easily think it a plane, as the ancients thought our earth, and so their geometry would be the same as Euclid's.

But, if they were originally created so large in proportion to their spherical surface as to be immediately affected by its positive curvature, then they would never gather any experience of parallel lines, or of geometrical similarity between figures of different sizes. A straight line being the shortest distance between two points, then all their straight lines or geodesic lines would return upon themselves; and as also any two straightest lines on a sphere must meet somewhere, our imaginary surface men could never learn our theory of parallels and geometry, unless, as has been suggested, they should produce mathematicians sufficiently powerful first to imagine and investigate a surface in which two straight lines might be drawn so as to remain at the same distance apart to infinity; that is, if they could in any way be supposed to have the idea of infinity. Then, as Land says: "Reasoning on this, and a few more suppositions, they might discover the analytical geometry of the plane. Combining this with their original spherical theorems, some genius among them might conceive the bold hypothesis of a third dimension in space, and demonstrate that actual observations are perfectly explained by it. Henceforth there would be a double set of geometrical axioms; one the same as ours, belonging to science, and another resulting from experience in a spherical surface only, belonging to daily life."

In reference to our own science of to-day, the two analogous questions are:

1. May we not be drawing wrong conclusions about space from our limited experience of space, just as the Greeks concluded that the earth was flat?

2. If our conclusions so far are true, yet may there not be, in addition to the three dimensions we know, still another or fourth dimension in space?

The idea of space of four dimensions has been successfully used by Salmon, Clifford, and Sylvester, in their researches, and Cayley has published "Chapters in the Analytical Geometry of n Dimensions." Spaces of two and three dimensions with constant curvature have been carefully investigated by Beltrami, Helmholtz, and now Frankland. I mention these as among the most important and easily procurable writings on the subject. In reality there have been about a hundred books and memoirs treating of new or non-Euclidean space.

Of that kind of non-Euclidean surface now being discussed in *Nature*, a very pretty idea may be obtained by likening it to a hemisphere on which, when any moving point has reached the edge, it is supposed, without any jump or any further motion, to have reached the corresponding point on the opposite edge, so that the meridians, great circles, shortest lines, instead of intersecting twice, as they do on the earth, only intersect once and yet return upon themselves. This, like the sphere, is called a surface of positive curvature, in reference to the plane, which has no curvature.

Now, just as to the plane corresponds an uncurved or homaloidal space, so to a surface of positive curvature corresponds a space of positive curvature; and if the space in which we live can be proved to have the slightest positive curvature, it instantly follows that the universe is only finite in extent, and that every physical straight line, for example, every ray of light, if sufficiently produced, returns into itself.

Yours very truly,

GEORGE BRUCE HALSTED.

JOHNS HOPKINS UNIVERSITY,
BALTIMORE, *May* 20, 1877.

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## "THE EARLY MAN OF NORTH AMERICA."

*To the Editor of the Popular Science Monthly.*

IN an article in your March number, upon "The Early Man of North America," the writer says of the Esquimaux, "They are from their speech a branch of the Turanian family, and allied to the Hungarian, Turkish, Lapp, and Basque races." Whitney, in his work on "Life and Growth of Language," says of the Basque: "It stands entirely alone; no kindred having been found for it in any part of the world." He further says: "Attempts have been made to connect them" (the American languages) "with some dialect or family in the Old World, but with obviously unavoidable ill success. . . . There appears to be no tolerable prospect that, even supposing the American languages derived from the Old World, they can ever be proved so, or traced to their parentage." In the same article there is the statement that the Esquimaux "extend in scattered companies for nearly five hundred miles on the coast of Asia beyond Behring's Straits," while other writers assert that the Esqui-

maux have no kindred on the Eastern Continent.

As the philosopher of the nineteenth century claims that "in his hands theory is never divorced from fact," we who are not philosophers complain, as we have the right to do, when they flatly contradict each other and furnish no evidence to fortify their statements. We accept their dicta so long as they agree, but we object to a dictum which contradicts another dictum equally respectable. D. A. HULETT.

NEW YORK, *May* 12, 1877.

## EDIBLE MUSHROOMS.

*To the Editor of the Popular Science Monthly.*

SIR: In the paper on "Mushrooms," etc., in the last number of your MONTHLY, I think Mr. Julius A. Palmer, Jr., uses the name of "Dr. Curtis, of South Carolina," for that of the great mycologist, Dr. Moses A. Curtis, of North Carolina, in connection with letters written to Mr. Sprague on "Mushrooms." Whether that is so or not, I am safe in saying that during our late war Dr. Moses A. Curtis wrote a work on "The Edible Fungi of North Carolina," illustrated with colored drawings by his son (I believe the Rev. Charles Curtis), and this manuscript work is still in existence. It is the result of Dr. Curtis's botanical investigations, as well as of his personal experience, as to which of the mushrooms are fit to eat. Many times, I am told, the good doctor had uncomfortable symptoms after trying a new mushroom, but you may be sure he did not stop until he learned more about it. His researches were begun in the war with a view to furnish such information to his people as would enable them to recognize edible mushrooms, and so supplement the poor diet so universal among even the better classes, but I believe he never cared to publish the work. I deem it but justice to the memory of Dr. Curtis to make this statement. THOMAS F. WOOD.

WILMINGTON, NORTH CAROLINA, *April* 30, 1877.

*To the Editor of the Popular Science Monthly.*

SIR: Will you permit a suggestion as to Mr. Herbert Spencer's descriptive term "negatively quantitative," and his specifications under it? It appears to me to belong to an undesirable class of definitions, because its defining part consists not only in asserting the absence of something, but in so asserting it as to require just as much the assertion of all the other absences that exist. That is to say, Mr. Spencer's definition, and his explanations of it, as cited in the MONTHLY of March, page 611, appear to me to necessarily imply the following preliminary proposition (which I do not think Mr. Spencer meant to imply): "A definition may consist of a statement that a single quality or characteristic is excluded from the thing defined." Now, of course, a definition, to be a good one, must accomplish two things, neither of which the above is: it must specify the qualities which the thing defined does possess; and it must exclude—not some one other, but—*all* others.

Further: is not the term "negatively quantitative" liable to be misunderstood from ambiguity? It seems to me that it may honestly be taken to mean either of the two following:

1. Being such as to exclude dealing with quantity or quantities.

2. Being such as to include, so far as it does deal with quantities, only what are called "negative quantities."

These are, of course, quite different meanings. It appears to me that Mr. Spencer applied the former, and that Mr. Halsted, in his communication to you, had in his mind the latter. If so, a misunderstanding was pretty likely.

I need not explain the benefit of avoiding the use for one purpose of terms already employed for another. And as I am a sincere admirer of Mr. Spencer, and of his great contributions to the advancement of sound thought, I hope you will not suppose I want to do anything in the way of attacking or fault-finding. F. B. P.

BOSTON, *April* 8, 1877.

## THE HABITAT OF THE GAR-PIKE.

*To the Editor of the Popular Science Monthly.*

SIR: Since the publication, in the May number, of the first part of my article "Gar-Pikes, Old and Young," I have had information as to the occurrence of *Lepidosteus* in Black Lake, near Ogdensburg, New York; in the Patapsco River, Maryland, and in the Edisto, Ashepoo, and Combahee Rivers, South Carolina.

It being commonly supposed that *Lepidosteus* is rarely found outside of the Great Lakes or the Mississippi River and its tributaries, I shall be much obliged to your readers for any information as to its occurrence elsewhere. Particularly valuable would be facts as to the time and place of spawning; and the eggs or newly-hatched young are greatly desired.

BURT G. WILDER.

ITHACA, NEW YORK, *May* 10, 1877.

# EDITOR'S TABLE.

### THE STUDY OF NATURE IN SCHOOLS.

THE progress of scientific education is slow, but the evidences of its reality are unmistakable. Among the recent and most encouraging illustrations of it, we note the various arrangements in different colleges for making excursions and expeditions for observation and the collection of specimens by students who are sufficiently interested to extend their studies in these directions. The excursions are to be in charge of competent professors, and the time of vacation is to be devoted to the work. The idea is excellent, as it will combine the pleasure of travel and out-of-door activity with valuable mental acquisition, which need not be so close or severe as to neutralize the advantages of vacation. It is especially in geology and natural history that the benefits of such excursions will be most obvious. In the former of these sciences, field-observation and the inspection of rocks, minerals, and landscape features in different localities, are requisite to give reality to knowledge and redeem the study from the illusiveness and unreality of its pursuit in mere text-books. Botany and zoölogy also are subjects which call their devotees into field and forest, mountain and valley, and require a kind of peripatetic cultivation. These vacation excursions, half for pleasure and half for profit, are valuable indications both of the increasing interest of this class of mental pursuits, and of an increasing appreciation of the only proper method of carrying them forward; while the friends of science have reason for congratulation at these signs of improvement in rational scientific culture.

But the obverse of this picture should not be overlooked. We cannot conceal from ourselves that these excursions are things to be thankful for, very much because of the defects of normal study throughout the year. Of course the vacation is a season of liberty, and allows a range of wandering which school confinement does not permit; and it is possible that excursion-work may be nothing more than a freer extension of the habitual practice in the school—which, of course, is the way it should be. Yet the open study of Nature, in her living objects, is undoubtedly, in most cases, rather a contrast to college experience than a continuation of it. It is to be remembered that the college has still a definite somewhere in Nature, from which the student can have an outlook upon realities, although the traditional scholarship makes little account of this circumstance. There are natural objects enough at hand, and crowding the collegiate environment, to illustrate a wide range of scientific study, if it were the policy of these institutions to make such objects available for this purpose. It is well to go away to find and examine new things, where that is convenient, or where it may be specially necessitated; but it should not be held to imply that there are not abundant facilities all around and everywhere for securing the same general object. The study of Nature is beginning to be *recognized* as an important part of common education, but it remains yet to be *organized* for this end.

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### THE ACCUSATION OF ATHEISM.

IT has been suggested that, if Dr. Draper had entitled his book "A History of the Conflict between Ecclesiasticism and Science," instead of "between

Religion and Science," he would have disarmed criticism, and saved himself from a great deal of theological abuse; but he preferred to credit people who profess religion with having it and being influenced by it, in their treatment of science. There is, indeed, no ground for impeaching the general sincerity of religious people who are alarmed at the advancement of science, and denounce it as subversive of faith. Their difficulty is simply that of narrowness and ignorance, inspired by a fanatical earnestness. Atheism has now come to be a familiar and stereotyped charge against men of science, both on the part of the pulpit and the religious press. Not that they accuse all scientific men of atheism, but they allege this to be the tendency of scientific thought, and the outcome of scientific philosophy. It matters nothing that this imputation is denied; it matters nothing that scientific men claim that their studies lead them to higher and more worthy conceptions of the Divine power, manifested through the order of Nature, than the conceptions offered by theology. It is enough that they disagree with current notions upon this subject, and any difference of view is here held as atheism.

In this, as we have said, the theologians may be honest, but they are narrow and bigoted; and it is surprising that they cannot see that, in arraigning scientific thinkers for atheism, they are simply doing what stupid fanatics the world over are always doing when ideas of the Deity different from their own are maintained. And it is the more surprising that Christian teachers should indulge in this intolerant practice, when it is remembered that their own faith was blackened with this opprobrium at its first promulgation. In a very able article by Prof. Zeller, of Berlin, on "The Contest of Heathenism with Christianity," reprinted in THE POPULAR SCIENCE SUPPLEMENT, No. II., this interesting subject is taken up, and the writer remarks upon it as follows:

"To the heathen nations, the Christians were in the first place atheists; for in every age this name has been given to those who did not agree with the prevailing conceptions of the Deity; not only when they denied his existence, but when they sought to instill a more just and worthy idea of God. 'Down with the atheists!' this was the war-cry of the heathen mob against the Christians. It was with this cry, for example, that in A. D. 156 the venerable Bishop Polycarp was received on the race-course at Smyrna. The only gods the people knew anything about, whose temples they frequented, whose statues they worshiped, to whom they offered sacrifices and prayers, were denied by the Christians; they were declared to be the inventions of man's superstition, and sometimes to be evil spirits, devils. Can we wonder that the people who were still devoted to these gods felt the attack upon them to be an attack upon themselves, their most sacred and cherished possessions; that they were the more deeply incensed at it the more seriously they feared by toleration of it to lose the favor of the gods on whom their welfare depended? The reproach of atheism was therefore the most dangerous that could be brought against the Christians. In that 'Down with the atheists!' with which the yells of the mob greeted Polycarp at Smyrna, was included the sentence of death, which they at once proceeded to execute by preparing the stake. And the cry was followed in numberless cases by the same results. If any public misfortune, any alarming event occurred, which seemed to indicate the displeasure of the gods—a pestilence, a dearth, a flood, an eclipse, an earthquake—superstition was always ready to make the Christians responsible for it, as enemies of the gods; the exclamation was sure to be heard, 'The Christians to the lions!' Both the educated and uneducated have always attributed every other wickedness to the enemies of the gods, and so it was with the Christians. Being atheists, they were also criminals, and all manner of horrible stories were told of them. It was not enough that they were said to worship a god with the head of an ass, which we see represented to this day in a caricature of that period, the well-known mock crucifix in the Kircher Museum at Rome; it was said, also, that in their secret assemblies they practised all sorts of

horrors, killed and devoured children, and gave themselves up to frightful excesses. Scarcely any evils were attributed to the Jews in the middle ages by Christian fanatics which had not been before attributed to the Christians by heathen superstition."

It would be well if our theologians would remember these things when tempted to deal out their maledictions upon scientific men as propagators of atheism. For the history of their own faith attests that religious ideas are a growth, and that they pass from lower states to higher unfoldings through processes of inevitable suffering. It was undoubtedly a great step of progress from polytheism to monotheism; as it was cartainly a most painful transition to lose the idea of a social hierarchy of human or superhuman immortals constantly mixed up with human affairs and the working of Nature, and to substitute the idea of a solitary divine personality, related to mankind chiefly through a special theological scheme. But this was neither the final step in the advancement of the human mind toward the highest conception of the Deity, nor the last experience of disquiet and grief at sundering the ties of old religious associations. But if this be a great normal process in the development of the religious feeling and aspiration of humanity, why should the Christians of to-day adopt the bigoted tactics of heathenism, first applied to themselves, to use against those who would still further ennoble and purify the ideal of the Divinity? It cannot be rationally questioned that the world has come to another important stage in this line of its progression. The knowledge of the universe, its action, its harmony, its unity, its boundlessness and grandeur, is comparatively a recent thing; and is it to be for a moment supposed that so vast a revolution as this is to be without effect upon our conceptions of its Divine control? Is it rational to expect that the man of developed intellect, whose life is spent in the all-absorbing study of that mighty and ever-expanding system of truth that is embodied in the method of Nature, will form the same idea of God as the ignorant blockhead who knows and cares nothing for these things, who is incapable of reflection or insight, and who passively accepts the narrow notions upon this subject that other people put into his head? As regards the Divine government of the world, two such contrasted minds can hardly have anything in common. "As a man thinketh, so is he;" and as a man is, so will he think. If he is ignorant and stupid, his contemplation of divine things will reflect his own low limitations. He will cling to a groveling anthropomorphism and conceive of the Deity as a man like himself, only greater and more powerful, and as chiefly interested in the things that he is interested in. If he delights in the pious excitement of "revivals," he will think of the Almighty as the patron of camp-meetings, and as watching from on high with special solicitude the doings of Moody and Sankey in Boston. It is superfluous to say that men who look upon the universe as science has disclosed it cannot much sympathize with this view of the Deity and all that it implies. The profound student of science will rise to a more spiritualized and abstract ideal of the Divine nature, or will be so oppressed with a consciousness of the Infinity as to reverently refrain from all attempts to grasp, and formulate, and limit the nature of that which is "past finding out," which is unspeakable and unthinkable. Religious feeling may be awakened in both those minds; but its inspirations and its accompaniments will be as wide asunder as the poles. Our religious teachers ought in these days to have liberality enough to recognize this serious fact, and remembering that human nature is religiously progressive, as well as progressive in its other capacities, should abstain from copying the

bad example of narrow-minded heathen thousands of years ago, who treated the Christians very much as many Christians now treat those who are devoted to the gospel of science.

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### THE FAMILY AND THE STATE.

We commend to those students of social questions who are interested in their scientific aspects the essay "On the Evolution of the Family," by Mr. Herbert Spencer, which was begun in the June MONTHLY, and is concluded in our present number. The article is an instructive illustration of what is properly meant by social science, and it also shows what is gained for the subject by investigating its phenomena from the standpoint of evolution. It is obvious that we can know little of the nature of the family until we have a right idea of its origin; and it is equally evident that it cannot be intelligently and wisely dealt with, either by social or political arrangements, on a false theory of its derivation and consequent erroneous views of its constitution. It is a current belief that the family is as old as humanity, and is an indestructible element of human society, and much the same thing everywhere. Even such inquirers into the philosophy of political history as Mr. Maine commence their researches by assuming the family or patriarchal group as a starting point. But on the theory of evolution this form of the domestic relations must be accounted for. The patriarchal condition was an outgrowth of earlier conditions, the complex resultant of a preëxisting state which there is reason to believe was far more prolonged than the period that has elapsed since the family was instituted. Be that as it may, the point of view now gained is that of the family as a growth, a product of the slow interaction of various natural agencies, and an institution therefore that is liable to impairment, disintegration, and decay.

This conception of the family gives an interest to the question of its relation to the state that no other hypothesis enforces. The family is older than the state, and grew up without it by natural laws and through long domestic experience and social discipline. The state is a subsequent development, a new direction of the power of society which is liable to be so exercised as to disturb and modify in serious ways the domestic relations. A child cannot build a house, but it can burn it down; the state did not make the family, but it can mar and destroy it. If, as Mr. Spencer alleges, "the salvation of every society depends on the maintenance of an absolute opposition between the *régime* of the family and the *régime* of the state," governmental tendencies become a matter of the gravest social concern. And these considerations acquire additional force in a country like this, where the whole people are given over to politics, and where there is a universal passion for experimenting with society under a superstitious delusion in regard to the omnipotence of legislation. If the principle laid down by Spencer be a true one, then are the functions of government sharply limited, and, by transcending them, the state to that extent usurps domestic functions, and becomes destructive of the family. The family grew up and became consolidated, as we may say, under pressure of necessities and responsibilities that could not be escaped, as there was no state upon which parents could roll off their burdens. But the state has come, and besides its essential duty of protecting the common rights, it is becoming more and more called upon to take care of the people, to improve the condition of the people, to take charge of their children, in short to assume the "parental" function. We have already gone so far in our state meddling with the work of education and relieving parents from the responsible care of their children, that the demand is now urgently made by

progressive teachers and advanced educational reformers that the government shall follow out the policy to its logical and consistent consequences, and assume the complete educational control of the young. From the time of weaning to graduation, the state (that is, the politicians who at any time happen to be in office) will hire the teachers and pay them, prescribe the studies, furnish the books, build the schoolhouses, and administer the discipline by which character is to be formed. This is an invasion of the domestic sphere, and an abrogation of those domestic functions by which the family was called into existence and has ever been maintained. Our school system is applauded on account of its imposing parade of statistics, its profuse expense, and the millions of children that the state has got charge of; but, when its indirect influences are taken into account, it may be found that, like most other human contrivances, it entails evil as well as good. Which shall preponderate, it remains for time to tell.

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## LITERARY NOTICES.

NEW LANDS WITHIN THE ARCTIC CIRCLE. Narrative of the Discoveries of the Austrian Ship Tegetthoff, in the Years 1872–1874. By JULIUS PAYER, one of the Commanders of the Expedition. With Maps and numerous Illustrations, from Drawings by the Author. Pp. 399. New York: D. Appleton & Co. Price, $3.50.

THE honor will be unhesitatingly accorded to Lieutenant Payer of having written the most deeply-interesting volume that has yet appeared on arctic adventure and exploration. We have rarely been so fascinated by a book of any kind, upon any subject. The experiences of the party were tragic and of thrilling intensity, and the narrative of them is in a remarkable degree vivid and graphic; so that, with the numerous and admirable illustrations, all drawn on the spot from Nature, we are made deeply to participate in the feelings of the heroic group of adventurers who were so long locked up amid the terrible desolations of Nature in the arctic region.

In a preliminary notice by the translator, the leading features of the expedition are thus summarized:

"The interest which will be excited afresh in arctic discovery and adventure will doubtless sharpen the interest in the volumes which record the fortunes of the Austrian Expedition; and we venture to affirm—without undue partiality—that, though the history of arctic exploration and discovery abounds in records of lofty resolution and patient endurance of almost incredible hardships, the narrative of the voyage of the Tegetthoff will be found to fall below none in these high qualities. The mere destiny of the vessel itself equals, if it does not exceed, in the element of the marvelous, anything which has before been recorded. Surely this is borne out when we think that, on August 20, 1872, the Tegetthoff was beset off the coast of Nova Zembla; remained a fast prisoner in the ice, spite of all the efforts made by her officers and crew to release her; drifted, during the autumn and the terrible winter of 1872—amid profound darkness—whither they knew not; drifted to the 30th of August in the following year (1873), till, as if by magic, the mists lifted, and, lo! a high, bold, rocky coast—latitude 79° 43′ north, longitude 59° 39′—loomed out of the fog, straight ahead of them. Close to this land—which could be visited with safety only twice, on the 1st and 3d of November of that year—the ship remained still fast bound in the ice. Not till the winter of 1873 had passed, and the sun had again returned, was it possible to explore the land which had been so marvelously discovered. On the 10th of March, 1874, the sledge-journeys commenced, and terminated May 3d, after 450 miles had been passed over, and the surveys and explorations completed, which enabled Payer to write the description of Kaiser Franz-Josef Land (pp. 258-270), which shows that other still undefined lands, with an archipelago of islands, have been added to the geography of the earth."

For more than two years the party were prisoners in their ship, of which they had lost all control, and, after passing two horrible winters in this distressing helplessness, it became clear that they must quit the ship or perish, and, in fact, there was small hope of saving their lives even by leaving it. Three boats were loaded with necessaries, and they started, May 20th, to dig their way through the deep snows and amid the mountainous ice-hummocks to open water. We extract from Payer's diary:

"The first day's work for twenty-three men, harnessed to boat or sledge, was the advance of one mile; and even this rate of progress, small as it was, was not constant. Many days it did not amount to half a mile. The sledges sank

deep and stuck fast in the snow. We had to pass three times heavily laden, and twice empty, over every bit of the road, and half our number were scarcely able to move a sledge or boat. After the exertion of some days, raw wounds appeared on the shoulders of several, and, to add to our trials, we suffered intensely from thirst. Nine men were sent back to the ship to bring away the jolly-boat and more stores, and it took just three hours to do the distance which it had cost the advance party eight days to accomplish. On our return to the boats, we found their crews were sitting up, and looking out like young birds in a nest, to see what we had brought from the ship. . . . Happy the man who has any tobacco; happy he who after smoking his pipe does not fall into a faint; happy, too, the man who finds a fragment of a newspaper in some corner or other, even if there should be nothing contained in it but the money-market intelligence, or, perhaps, directions to be followed in the preparation of pease-sausage. Enviable is he who discovers a hole in his fur coat which he can mend; but happiest of all are those who can sleep day and night. Of these latter, some have stowed themselves away under rowing-seats, and above them reposes a second layer of sleepers; but nothing is visible of either party but the soles of their feet. . . . The end of the Franklin Expedition, and the history of the two skeletons which were found in the boat, is told again for the twentieth time—a story which never fails to produce a harrowing effect, and to rouse the firm and resolute to yet greater efforts and self-command. . . . One solace is left us—the solace of smoking. Some, indeed, have exhausted their whole stock of tobacco. He who has half a pouch of it at his disposal is the object of general respect, and the man who can invite his neighbor to a pipe of tobacco and a pot of water is considered to do an act of profuse liberality. Tobacco becomes a medium of exchange among us, and provisions are bought and paid for with it, its value rising every day. There is no difference between day and night, and Sundays are only distinguished by dressing the boat with flags. In this enforced idleness passed away the days between the 9th and 15th of June, save that on the 14th we changed our place by three hundred yards, in order to select a more convenient spot for seal-hunting, and to keep up the appearance of traveling."

The unparalleled hardships of this struggle may be inferred from Lieutenant Payer's remark, page 364, that, "*after the lapse of two months of indescribable efforts, the distance between us and the ship was not more than nine English miles.*"

But the open sea was at length reached, and on the 15th of August the boats were dressed with flags, ballasted, the sledges left behind, and the expedition put off. The party had passed ninety-six days in the open air after leaving the Tegetthoff, when a small boat was descried, with two men in it, apparently engaged in bird-catching; and, upon turning the corner of a rock, two ships were discovered, within a few hundred yards. They were Russian vessels, engaged in salmon-fishing; and the strangers were received on board with mingled feelings of wonder and sympathy. Lieutenant Payer remarks:

"No grandees could have been received with more dignity than we were. At the sight of the two ukases which we had received from St. Petersburg, and which required all inhabitants of the Russian Empire to furnish us with all the help we needed, these humble seamen bared their heads and bowed themselves to the earth. We had an example before us to show how orders are obeyed by the subjects of that empire a thousand miles from the place where they were issued. But we were received not only in this reverential manner, but were welcomed with the greatest heartiness, and the best of everything on board was spread before us—salmon, reindeer-flesh, eider-geese, eggs, tea, bread, butter, brandy. The second skipper then came on board, and invited us to visit him—the first of a series of invitations. Dr. Kepes was very pressingly invited, for he had a sick man on board his vessel, and our doctor returned with an *honorarium* of tobacco in his hand. These simple Russian seamen of the arctic seas freely produced their little stock of good things to give us pleasure; and one of them, after observing me for a long time, and thinking that I did not express myself sufficiently strongly for a happy man, persuaded himself that something was the matter with me, and that I wanted something. Forthwith he went to his chest, and brought me all the white bread he had, and the whole remaining stock of his tobacco. Though I did not understand a word he said, his address was full of unmistakable heartiness, and so far needed no interpreter."

We have preferred to let the author of this work speak for himself rather than to attempt any description of it, which would certainly be unsatisfactory within our narrow limits. But we may add that it is a volume of great scientific interest. For half a century arctic adventure has been inspired by a sentiment of rivalry to reach the pole, although more and more it has been recognized that its real object should be the extension of our knowledge of Nature under its remarkable arctic aspects. Lieutenant Payer has entered fully into this view; and his volume is not only charming as a narrative, but contains a great deal of important scientific information.

THE COOKING MANUAL; or, Practical Directions for Economical Every Day Cookery. By JULIET CORSON, Superintendent of the New York Cooking School. New York: Dodd, Mead & Co. Pp. 144. Price, 50 cents.

MISS CORSON has done well to give the public this result of her experience in culinary teaching, in a form so cheap that it may have the widest possible usefulness. She is a common-sense woman, and takes up the subject from a point of view that is thoroughly practical. The motto of her book is the following significant question, "How well can we live if we are moderately poor?" and it is the object of her little volume, as it has been the object of her school, so to present the subject of cooking and household management as to answer this question. Her object in preparing it is thus stated: "This book is intended for the use of those housekeepers and cooks who wish to know how to make the most wholesome and palatable dishes, at the least possible cost. In cookery, this fact should be remembered above all others—*a good cook never wastes*. It is her pride to make the most of everything in the shape of food intrusted to her care, and her pleasure to serve it in the most appetizing form. In no other way can she prove her excellence, for poor cooks are always wasteful and extravagant." To the prejudice against foreign ways of cooking Miss Corson replies very effectually, pointing out that the two great objects to be ever secured in the kitchen—the art of utilizing every part of food, and of making food the most palatable and enjoyable—are eminently French.

Miss Corson says, "The day has passed for regarding cooking as a menial and vulgar labor." She is very sanguine; we wish we could believe it. We wish we could see some more decisive signs that it is passing away; we wish we could see some faint indications that it will have passed away in a hundred years! Our school system stands in the way of it, and where are the symptoms of its decline?

Miss Corson's book is full of excellent information, scientific hints, practical suggestions, and plain receipts, descriptive of the preparation of many important dishes, and the publishers have got it up in a neat form, with good, clear type, that can be easily read. We believe it will be found eminently trustworthy as a kitchen handbook.

THE BEST READING: Hints on the Selection of Books; on the Formation of Libraries, Public and Private; on Courses of Reading, etc., with a Classified Bibliography for Easy Reference. Fourth revised and enlarged edition, continued to August, 1876, with the Addition of Select Lists of the best French, German, Spanish, and Italian Literature. Edited by FREDERICK BEECHER PERKINS. New York: G. P. Putnam's Sons. Pp. 348. Price, $1.75.

THIS guide will be valuable to all who buy books for private libraries or public collections. It has been tried and found successful. It names the best books now usually in the market in the chief departments, and on the leading topics of current and general literature, with their editions and retail prices. It is conveniently arranged for ready use, and will give the book-buyer a large amount of valuable information, that will help him in making judicious selections, either on the small or the large scale.

THE MILTON ANTHOLOGY: Selected from the Prose Writings. New York: Henry Holt & Co. Pp. 486. Price, $2.

MILTON'S prose works have been so eclipsed by his poetry that they are popularly known only by hearsay; yet so great is their merit, both in a literary point of view and as containing the most able and eloquent defense of civil and religious liberty which had been given to the world up to his time, that the plan of collecting some of his best papers in a handy volume like this deserves to be commended, and will no doubt be well appreciated. Though there is much in these writings that reflects the spirit and circumstances of the times which produced them, there is much also of permanent interest, and which will have an enduring place in English literature.

THE GEOMETRID MOTHS OF THE UNITED STATES. By A. S. PACKARD, Jr., M. D. Pp. 607. With numerous Plates. Washington: Government Printing-Office.

THIS elaborate work forms Volume X. of Dr. Hayden's "Report of the Geological Survey of the Territories." The author

notes a striking and unexpected similarity between the insect fauna of Colorado and the Ural and Altai Mountains. He believes that a careful examination of the existing insects of the Western country will throw light on the extinct forms which abound in the Tertiary of that region. From an economic point of view, he is of the opinion that a systematic account of the insect family which embraces the measuring-worms—so many of which are injurious to vegetation—cannot but be useful to agriculturists.

MORAL MAXIMS FOR SCHOOLS AND FAMILIES. By C. C. BALDWIN. Third edition. Pp. 16. Price 10 cents. Petersburg, Va.: Darcy, Paul & Co.

THIS little pamphlet raises no questions of ethics, but, assuming the fundamental canons of morality and rules of conduct, it aims to drive them home into the minds of the young by brevity and sharpness of statement, so as to make the most indelible impression. It is interspersed with interesting illustrations of the sayings and doings of great men, which serve to give interest to the work. The idea is a good one, and well carried out within its compass; it is used in the public free schools of Virginia, and is a candidate for adoption in primary schools everywhere.

THE SYMBOLICAL LANGUAGE OF ANCIENT ART AND MYTHOLOGY. By R. P. KNIGHT. Pp. 267. New York: J. W. Bouton. Price, $3.

THE so-called "pagan" religions of antiquity—the religions of Greece and Rome, of Babylonia and Assyria—so far as we get a knowledge of them from a superficial reading of ancient authors, appear to rest on a basis of childish imaginations, for their dogmatic side, while on their moral (or rather immoral) side they seem to have their roots in unbridled lust and debauchery. This view of pagan religions is still held by the vulgar, and not very long ago was current even among the learned. The author of the present work rendered valuable service to the philosophy of religion when, amid much obloquy, he devoted himself to a patient and dispassionate study of this subject, and showed that, like all other religions, those of antiquity were in their origin the expression of man's highest aspirations. Among the topics learnedly discussed by the author are the mysteries and orgies, phallic worship, the sacred emblems of the various gods, etc. The present edition of Knight's work is edited by Dr. Alexander Wilder, who adds an introduction, some notes, and a complete index. Further, the notes, which in the original edition are mostly in foreign languages, are here translated into English.

AN ANALYSIS OF RELIGIOUS BELIEF. By Viscount AMBERLY. From the late London edition. Complete. Pp. 726. New York: D. M. Bennett. Price, $3.

THE chief interest of this formidable volume lies in the fact that it is the production of a young English nobleman, who, notwithstanding the powerful influences brought to bear upon him to maintain his reputable position, chose to be free in the matter of thought, and had the courage to express and the determination to publish his opinions, regardless of their unpopularity. The volume indicates extensive and systematic reading, rather than much depth or originality of thought, and to persons who have a taste for skeptical literature it will have the freshness of an elaborate restatement of objections to religious dogma. Lord Amberly believes in the universality of the religious sentiment, as a part of the mental constitution of human nature—as a natural and not a supernatural thing—but he discredits its intellectual accompaniments as embodied in the doctrines and creeds of all religions. He professes to take the scientific standpoint, and to write in the scientific spirit, but we question if his book would take any rank as a scientific or authoritative contribution to the subject. Its scheme was too large, the man was too young, and had done no preliminary work in any of the special departments of science, to give him the power and maturity necessary to deal with so important a theme at the present time. Without comparing his work with that of Mr. Buckle, his position as regards science is not unlike that of the author of the "History of Civilization in England," who knew a great deal about scientific literature, and was much influenced by its method, but was not strong and thorough and well grounded in the

sciences which had a vital bearing upon the course of his large discussion. If Lord Amberly had concentrated himself upon some minor branch of his broad inquiry, and worked it out with deliberation, his chances of recognition in the future would probably have been much more promising than they will be with his more ambitious undertaking.

THE RADICAL REVIEW. Issued quarterly. Edited by BENJAMIN R. TUCKER. Pp. 204. Price, $5 per year. New Bedford, Mass.

THE first number of this periodical vindicates its radical and independent character. Its object is stated to be "the thorough, fearless, and impartial discussion of all sides of all subjects pertaining to human welfare, whether social, economic, scientific, literary, æsthetic, or religious." It will show no partiality to any particular school or special system of belief, but the labor question and the organization of industry will receive a prominent share of attention. It opens with an able paper, by W. J. Potter, on "The Two Traditions, Ecclesiastical and Scientific," of which the following passage is a good example:

"But this scientific view of tradition—now commonly styled the doctrine of evolution—starts questions that concern religious and moral faith more vitally than any we have yet considered. The objection that the dignity of the human race is assailed, if man be thus linked in natural kinship with the brute animals, is becoming antiquated, and needs no consideration. To ridicule the theory, and oppose those who hold it with theological abuse, neither intimidates scientific men nor abolishes the facts upon which they claim that the theory rests. To ask if you want a monkey for an ancestor may raise a laugh among the bystanders; but Science is not answered by a laugh, and does not consult the caprice of human wishes so much as the purport of Nature's facts. But even if it were a question of the dignity of the human race, it might be replied that it is better to have risen from an ape than, according to the popular theological theory, to have fallen from an angel. It is more honorable to be climbing up than slipping down. And there are species of animals with whom we might more proudly claim cousinship than with some specimens of mankind. But this concern lest human dignity is to suffer from any earnestly advocated theory of science is puerile."

Lysander Spooner furnishes a very incisive and unsparing article entitled "Our Financiers: their Ignorance, Usurpations, and Frauds," which cleaves the question through to first principles. A fine poem is contributed by Mr. E. C. Stedman; and the department of current literature is ably treated. It contains a discriminating review of Mr. J. N. Larned's "Talks about Labor, and concerning the Evolution of Justice between the Laborers and the Capitalists." We like this periodical, all except its dismal pall of a cover.

DYNAMICS. By J. T. BOTTOMLEY. Pp. 140. New York: Putnams. Price, 75 cents.

THE fundamental principles of "Dynamics," or theoretical mechanics, are here set forth and demonstrated as satisfactorily as it is possible to do so for the tyro in mathematical science. In cases where the subject-matter requires a higher degree of mathematical knowledge, the author contents himself with giving clear statements of propositions and of the meanings of formulas, reserving demonstrations for a time when the pupil will be better able to appreciate them.

SMITHSONIAN REPORT. 1875. Pp. 422. Washington: Government Printing-Office.

BESIDES the special annual report of the Secretary, Prof. Joseph Henry, this volume contains a number of memoirs and treatises on scientific subjects, both original and selected. Among the translated pieces are a "Eulogy on Alexander Volta," and De Candolle's "Report on the Transactions of the Geneva Physical and Natural History Society." Among the original contributions is a paper by Mr. Henry Gilman on "Ancient Man in Michigan;" and one by Dr. C. C. Abbott, on "The Stone Age in New Jersey." Both of these memoirs, and more especially the latter, are illustrated with numerous woodcuts.

VEGETABLE AND ANIMAL CELLULOSE. By THOMAS TAYLOR. Pp. 8. From *Field and Forest.*

THE author describes the method by which he detects the presence of cellulose in its various forms. This substance is, according to him, a constant ingredient in the organs and blood even of the higher animals, man included.

ACOUSTICS, LIGHT, AND HEAT. By W. LEES. Pp. 300. New York: Putnams. Price, $1.50.

THE student who is acquainted with the elements of mathematical and physical science will find this little work a very convenient manual for self-instruction in the branches of science of which it treats. The illustrations are very numerous, and greatly facilitate the understanding of the text.

PROCEEDINGS OF THE POUGHKEEPSIE SOCIETY OF NATURAL SCIENCE. Vol. I., Part I. Pp. 150.

THIS work contains a number of very valuable memoirs, among which may be named the following: "White Mildews," by W. R. Gerard, who also has a learned paper on "Insects as Food;" two papers on the "Thermoscope," by Prof. L. R. Cooley; "Habits of the Wasp, *Polistes fucatus*," by Rev. H. T. Hickok; "Fungus-Eating," by Dr. E. H. Parker; and "Inclination of the Earth's Axis," by C. B. Warring.

WESTERN REVIEW OF SCIENCE AND INDUSTRY. Monthly. Pp. 64. Kansas City, Mo.: *Journal of Commerce* print. Price, $2.50 per annum.

WE have received the first number of the above-named periodical, which we cordially welcome to the field of scientific journalism. It contains articles, original and selected, on topics connected with archæology, physiology, engineering, meteorology, and agriculture. The editor aims at filling his pages with useful and practical information for the people, conveyed in plain and simple language. This enterprise deserves, and we hope will receive, liberal support from the public.

ANALYSIS OF MILK. By E. H. VON BAUMHAUER. Pp. 34. New York: Trow & Son print.

WE have here, reprinted from the *American Chemist*, Dr. Carrington Bolton's translation of a paper read by Mr. Baumhauer at the Buffalo meeting of the American Association. It contains a description of a new method for determining the essential constituents of milk, especially designed for the use of chemists who may be called on to testify as experts in courts of justice.

MYELITIS OF THE ANTERIOR HORNS. By E. C. SEGUIN, M. D. Pp. 120. New York: Putnams. Price, $1.50.

THIS monograph is of interest only to medical men. The substance of it was contained in a lecture by the author, printed for private circulation only. In the present volume a number of new cases of the disease are cited.

THE METRIC SYSTEM. Pp. 12. Boston: Press of Rockwell & Churchill.

THIS is the report of a standing committee of the Boston Society of Civil Engineers, favoring the adoption of the metric system of weights and measures. The committee first report on the growth of this system in public favor; then they state the result of invitations to united action addressed by the Society to kindred organizations throughout the country; next follows the text of the Society's memorial to Congress praying for the enactment of laws establishing the metric system.

THE ANCIENT GLACIERS OF NEW ZEALAND. By I. C. RUSSELL. Pp. 13. With Map.

THIS is a paper reprinted from the "Annals" of the New York Lyceum of Natural History. The facts noted by the author seem to point to a time of extreme cold in the southern hemisphere, answering to the glacial epoch of the northern.

NATURAL HISTORY OF ILLINOIS. Pp. 76. With Plates. Bloomington, Ill.: Pantagraph Printing-House.

WE have here Bulletin No. 1 of the Illinois Museum of Natural History, containing papers on "Illinois Crustacea," "The Tree in Winter," "Sodic Pinate as a Test for Lime," a "Partial Catalogue of the Fishes of Illinois," "Parasitic Fungi," and "The Orthoptera of Illinois."

TOPOGRAPHICAL SURVEYS AND THE PUBLIC HEALTH. By J. T. GARDNER. Pp. 10. Albany: *Argus* print.

THE thesis here defended by Mr. Gardner is, that the sources of many prevailing diseases are to be found in various natural conditions of the earth's form and substance, as well as in soils polluted by man. The geographer and the physician must work together in the study of the public health.

GEOGRAPHICAL SURVEYS IN THE UNITED STATES. By G. K. WARREN. Pp. 28. Washington: Judd & Detweiler.

GENERAL WARREN here undertakes to "correct the erroneous estimate of the geographical work of officers of the United States, made by one of our countrymen," viz., Prof. J. D. Whitney, in his article on "Geographical Surveys," which was published in the *North American Review* for July, 1875.

REPORT OF THE NEW YORK METEOROLOGICAL OBSERVATORY (1874–'75.) By D. DRAPER.

MR. DRAPER gives a description of an improvement in the rain-gauge, and of a self-recording pencil thermometer — both being the fruits of his own researches and mechanical ingenuity. The report further contains the usual annual and monthly tables of meteorological phenomena.

A CENTURY'S PROGRESS IN AMERICAN ZOÖLOGY. By A. S. PACKARD, Jr. Pp. 8.

PROF. PACKARD, within the narrow limits of this too brief essay, contrives to give a very readable account of the progress of zoölogy in the United States. To Barton he assigns the honor of being the first American zoölogist whose works have been published here. Barton's memoir on the "Fascination of the Rattlesnake," and on the "Generation of the Opossum," appeared, the first in 1796, and the second in 1801. At present zoölogy in the United States is, according to Prof. Packard, very backward as compared with Germany, France, and England. We are about on a level with the Scandinavians and the Dutch; but, with our energy and native ability, and the aid of well-endowed colleges and museums, we may hope hereafter to compete even with Germany.

KINDERGARTEN MESSENGER. Cambridge: Elizabeth P. Peabody. Pp. 32. Six numbers a year. Subscription price, $1 per annum.

IT is to be hoped that the energetic editor and publisher of this useful magazine will receive such encouragement from the public as will warrant her in continuing its publication. The Kindergarten system has no more able exponent in the United States than Miss Peabody.

## PUBLICATIONS RECEIVED.

Gold and Debt. By W. L. Fawcett. Chicago: S. C. Griggs & Co. Pp. 270. Price, $1.75.

Handbook of Hygiene. By G. Wilson, M. D. Philadelphia: Lindsay & Blakiston. Pp. 520. Price, $3.50.

Turkey. By J. Baker. New York: Holt & Co. Pp. 515, with Two Colored Maps. Price, $4.

Annual Record of Science and Industry. By S. F. Baird. New York: Harpers. Pp. 845. Price, $2.

Lightning Protection. By H. W. Spang. Philadelphia: Claxton, Remsen & Haffelfinger. Pp. 180. Price, $1.50.

Ancient Society. By L. H. Morgan, LL. D. New York: Holt & Co. Pp. 576. Price, $4.

Anonymous Hypothesis of Creation. By J. J. Furniss. New York: C. P. Somerby. Pp. 54.

Personal Immortality. By J. Oppenheim. New York: C. P. Somerby. Pp. 98.

Theoretical Chemistry. By Dr. Ira Remsen. Philadelphia: H. C. Lea. Pp. 232. Price, $1.25.

Primer of Chemistry. By A. Vacher. Philadelphia: Lindsay & Blakiston. Pp. 116. Price, 50 cents.

Forces of Nature. Part I. By A. Guillemin. New York: Macmillan. Pp. 40, with Illustrations. Price, 40 cents.

Atlas of the Geology of a Portion of the Uinta Mountains. By J. W. Powell. New York: Julius Bien, lithographer.

Report of Ohio State Fish Commission. Columbus: Nevins & Myers print. Pp. 96.

Ages of Sun and Fixed Stars. Pp. 4. Meteoric Fireballs. Pp. 7. By D. Kirkwood.

Utah Dialects. By E. A. Barber. Extracted from Hayden's Reports. Pp. 13.

Physiology of the Brain. Pp. 15. Reflex Motor Symptoms. Pp. 16. By Dr. E. Dupuy. New York: Appletons.

Errors of Refraction. By Dr. F. A. Munson. Albany: Riggs print. Pp. 11.

Valuation of Fertilizers. By A. R. Ledoux. Raleigh, N. C.: *Observer* print. Pp. 15.

Western Diptera. By C. R. Osten-Sacken. From Hayden's Reports. Pp. 163.

Report of the Directors of the Philadelphia Zoölogical Society. Pp. 36.

Growth of Children. By Dr. H. P. Bowditch. From Massachusetts Health Board Report. Pp. 51.

Kings County Medical Society Proceedings. Pp. 18.

Eruptive Mountains in Colorado. By Dr. A. C. Peale. From Hayden's Reports. Pp. 14.

Bulletin of the Geographical and Geological Survey of the Territories. T. V. Hayden in charge. Vol. III., No. 1, pp. 185; No. 2, pp. 339. Washington: Government Printing-Office.

Bulletin I. of United States Entomological Commission. Washington: Government Printing-Office. Pp. 12.

Quadrature of Circle. By R. K. Carter. Chester, Pa.: Spencer print. Pp. 12.

Rules of English Conversation Club at Kolozsvar. Pp. 19.

Johns Hopkins University Second Annual Report. Pp. 50.

Blue-Glass Cure. By Dr. E. B. Foote. Pp. 68. Price, 10 cents.

Overturning the World. By Dr. G. M. Ramsey. New York: McBreen print. Pp. 27.

Dakota Calendar. By Lieutenant-Colonel G. Mallery. From Hayden's Reports. Pp. 25.

Paleontological Paper. By Dr. C. A. White. From Hayden's Reports. Pp. 30.

Sugar-Refinery of Havemeyers & Elder. From "Industrial America." Pp. 18.

Report on the Retreat for the Insane. Hartford, Conn.: Case, Lockwood & Brainard Co. print. Pp. 36.

Steam-Engine. By F. J. Bramwell. London: Macmillan. Pp. 62. Price, 6*d*.

Distilled Water from Service-Steam. By C. E. Munroe. From *American Chemist*. Pp. 12.

Superficial Deposits of Nebraska. By Dr. S. Angbey. From Hayden's Reports. Pp. 31.

Self and Cross Fertilization of Flowers. By T. Meehan. Pp. 8.

Circular Eight of Johns Hopkins University. Pp. 12

*The New Century*. Pp. 46. $1 a year.

Natural Resources of the Black Hills. By W. P. Jenney. Washington: Government Printing-Office. Pp. 71.

Proceedings of American Chemical Society. Vol. I., No. 3. Pp. 77.

*Pennsylvania College Monthly*. Gettysburg: Wible print. Pp. 28.

Vick's Floral Guide, Rochester, N.Y. Pp. 30.

Poisonous Mushrooms. By Dr. I. Ott. Pp. 6.

## POPULAR MISCELLANY.

**Reopening of an Old Route into Siberia.**—Fully three hundred years ago the Russians carried on an extensive trade between Archangel and the settlements on the Obi and Yenisei. About the same period the Kara Sea was navigated by English and Dutch mariners, in search of a northeast passage to Japan. The Russians employed wretched flat-bottomed boats, called *kotchkies*, and in these they braved all the dangers of navigating the stormy Kara Sea. But, till quite lately, this route to the interior of Siberia was abandoned, and the belief was generally entertained that the existence of ice in the Kara Sea presented an insuperable obstacle to navigation. Recent expeditions to the mouths of the Obi and Yenisei, and up those rivers for hundreds of miles, have demonstrated the entire feasibility of this route to the interior of Siberia. The influence of the Gulf Stream and equatorial currents on the temperature of the Kara Sea is apparent from the fact that its waters are as much as 18° or 20° warmer than the waters in the same latitudes off the east coast of Greenland or in Davis's Strait. Of Siberia, the country to be opened up to commerce by the navigation of the Kara Sea, M. de Lesseps declares that it is the richest country in the whole world as regards its vegetable, mineral, and animal products. The great rivers of Siberia flow from the south to the north, forming a vast fan which widens in the interior of the country, to the great advantage both of vegetation and of commerce. The Obi, with its confluent the Irtish, affords a navigable highway into China.

**The Art of the Farrier.**—It is with regret that we are forced by want of space to present to our readers, in the unsatisfactory shape of a synopsis, a valuable article on "The Art of the Farrier," by Dr. D. D. Slade, published in the *Bulletin of the Bussy Institution*, vol. ii., Part I. In the state of Nature, we are there told, the growth and wear of the horse's hoof are in perfect equilibrium; in the domesticated state wear exceeds growth, and some means of protection must be devised. But this again destroys the balance, and growth is in excess. This excess must be removed either by natural wear of the bare hoof or by artificial means. The farrier's art consists in removing this excessive growth. The hoof of the young animal, before it has been shod, needs little or no preparation from the farrier's hands. The foot that has already been shod must have the nails extracted, and its ground surface cut down to the proper level. The growth is greatest at the toe; in leveling the wall, reduce the hoof at the toe to a level with the unpared heel. The shoe must not remain on the hoof more than one month at a time.

The heel seldom needs paring away, being usually worn away by the motion between the iron of the shoe and the horn. The process of "opening up" the heel destroys that portion of the foot which was designed by Nature as a defense against its contraction; this defense should never be mutilated. The practice of paring the sole and destroying the bars is to be condemned so long as the parts are healthy; it exposes the sensitive portions beneath to injury. The frog should be retained in its integrity. Rasping the wall after the application of the shoe cannot be too strongly condemned; it destroys the polish of the external layer of horn which protects the layers beneath, rendering the crust brittle.

The shoe ought to present a concave surface to the ground, and a plane surface to the foot. But, where the sole has been mu-

tilated by unskillful shoeing, the concave and plane surfaces have to be reversed. Whatever form is adopted, the shoe must fit the foot, its outline corresponding exactly to its ground-surface. The shoe must be of the same thickness throughout; where calks are required, they should be of equal height at heel and toe. The number of nails to each shoe, for a saddle or light-draught horse, need not be more than five or six in the fore and seven in the hind, but more widely distributed than they usually are. The hold of the nails should be short. The slight scorching of the horn-fibres by the application of a hot shoe has rather the effect of preserving them against untoward influences than of inflicting injury.

Disease often produces changes which require a modification of the system advocated above. In caring for the feet all that is needed is strict attention to cleanliness. They should be daily sponged with clear water, and afterward the parts above the hoof rubbed dry. The unmutilated sole forms in itself the best defense against the extremes of dryness or moisture, and "stuffing" and other artificial measures are worse than useless if the natural sole has been preserved. Placing the animal on a perfectly level floor will promote a sound condition of the feet, and conduce to the general health of the horse.

**A Plague of Rabbits in New Zealand.**—Some years ago rabbits were introduced into South Australia from England; later, a like importation was made into New Zealand. Now these rodents are a formidable pest in those countries, and it has become a question of extreme urgency how they can be exterminated. In New Zealand a commission has been instituted by the Government to inquire into the subject, and devise a remedy. Already, though only a few years have passed since the introduction of the rabbits, large tracts of rich pasture-land have been converted into wilderness, and sheep-farming and cattle-raising are becoming impossible. Farmers that used to keep 15,000 or 16,000 sheep can now hardly keep as many hundred. Land-owners employ men and dogs to destroy the rabbits, but, though the number killed is enormous, the evil continues without serious abatement. One land-owner inclosed with a stone-wall an area of 10,000 acres, the work taking seven years to complete, and involving an expenditure of £85,000. About 500,000 rabbit-skins were exported from Hobart Town in 1874. It is proposed to introduce from England, if possible, several natural enemies of the rabbit, such as stoats, weasels, ferrets, and hawks.

**Metric Weights and Measures in Massachusetts.**—Below we give the main provisions of a law recently enacted by the Legislature of Massachusetts, legalizing the metric system of weights and measures, in conformity with the laws of the United States. Other States, in legislating upon this subject, will doubtless frame their laws according to the model here set before them by the Commonwealth of Massachusetts:

SECTION 1. From and after the passage of this act, it shall be lawful, throughout the Commonwealth of Massachusetts, to employ the weights and measures of the metric system, and no contract or dealing or pleading in any court shall be deemed invalid or liable to objection because the weights or measures expressed or referred to therein are weights or measures of the metric system; and the metric weights and measures received from the United States, and now in the Treasury of the Commonwealth, may be used and taken as authorized public standards of weights and measures; and these authorized standards shall in no case be removed from the Treasury, except under necessity for their preservation or repair.

SEC. 2. The following tables shall be recognized in the construction of contracts, and in all legal proceedings, as establishing, in terms of the weights and measures now in use in the State of Massachusetts, the equivalents of the weights and measures expressed therein in terms of the metric system; and said tables may be lawfully used for computing, determining, and expressing, in customary weights and measures, the weights and measures of the metric system. (Here follow the tables.)

SEC. 3. The Treasurer is hereby authorized and directed to procure duplicate sets of the metric weights and measures, conformable to the standards now in the Treasury; of which two sets shall be retained for the use of the Treasurer and his deputy, and from which there shall be furnished one set to the treasurer of each shire town in the several counties of the Commonwealth, and each city not a shire town.

SEC. 4. The duties of the Treasurer of the Commonwealth and his deputy, and the duties and responsibilities of the treasurer of each town, with respect to the keeping, care, verification, and use of the standard weights and measures so furnished, shall be the same with

those established by existing statutes with respect to the standard weights and measures heretofore provided. And it is hereby provided that no shire town in which there may be two or more sealers of weights and measures shall for that reason be required to procure additional sets of the metric weights and measures.

SEC. 5. The deputy and Treasurer shall verify, adjust, and seal all metric weights and measures that may be brought to him for that purpose, and he shall receive a reasonable compensation therefor; and the sealer of weights and measures in each town that shall receive the standard metric weights and measures, as hereinbefore provided, shall verify, adjust, and seal all metric weights and measures that may be brought to him for that purpose from within the county in which such town is situated, and he shall receive a reasonable compensation therefor; but he shall claim no fees for any sealing, verification, or adjustment, for the performance of which he may otherwise receive compensation by salary paid by the town.

SEC. 6. All persons using weights or measures of the metric system for the purpose of selling any goods, wares, merchandise, or other commodities, shall have them adjusted, sealed, and recorded, by some authorized sealer of weights and measures, and shall thereafter be responsible for the correctness and exactness of the same; and no person using illegally or fraudulently the metric weights and measures shall thereby be freed from any liabilities or penalties to which he would have been exposed in case the weights and measures employed had been the ordinary weights and measures heretofore and now in use in this Commonwealth.

**Cleopatra's Needle.**—This obelisk, of Syenitic granite, sixty-eight and one-half feet long, six feet eleven inches wide on each side of the base, tapering to four feet nine inches near the summit, is 3,300 years old, and was set up by Sesostris in front of the temple at Heliopolis. It was brought to Alexandria by Cleopatra about the year 40, and has been there, standing or lying, upward of 1,800 years. It is of rose-colored stone, and is covered with hieroglyphics. It was presented many years ago by the Pasha of Egypt to the Prince Regent of England, and the British Government accepted the gift, but have never been able to get it transported to London. At length Dr. Erasmus Wilson, a distinguished surgeon of that metropolis, and known as the author of books on skin-diseases, concluded to pay the expenses himself of transporting the great monolith, and bargained with a Mr. Dixon to bring it to England and erect it on the Thames Embankment for £10,000.

The plan proposed for transporting the "Needle" to England is described as follows in *Chambers's Journal:* "The obelisk is to be fixed by cross-divisions or diaphragms of wood in a cylindrical vessel formed of wrought-iron plates. There will be seven diaphragms, and consequently nine water-tight compartments. For safety, the obelisk will be inclosed in wood and well packed, a little below the central level of the vessel, which will be closed at both ends. When completed, with the obelisk inside, the vessel will be about ninety-five feet in length and fifteen feet across. After being rolled into the sea and towed to the harbor, it will be ballasted and be provided with a keel, deck, sail, and rudder. For these operations, man-holes will have been left in the cylinder. These holes will be opened, so that access may be had to all the compartments. There will be no part into which a man may not enter if necessary until the cylinder is finally sealed up for floating. The vessel will be in charge of two or three skilled mariners, for whom a small cabin on deck will be provided. It will be towed the whole way by a steam-tug, the sail being simply for steadying the cylinder." There is likely to be some delay in executing this project, for it is now reported that the Egyptian who owns the sand around the obelisk objects to the removal of the shaft, claiming it as his property.

**Education and Crime.**—In a recent number of the *Polytechnic Review* is an abstract of a paper on "Useful Education," by Mr. R. Bingham, containing many facts and observations that are worthy of notice in these times of "forcing" in education. Mr. Bingham does not believe that school-education tends to diminish crime. He says that the ratio of crime to population is less in Ireland than in Massachusetts, and that property is more secure in Italy, with its many millions of illiterates, than in the Old Bay State with all its schools. Of the 373 prisoners received last year into the Western Penitentiary of the State of Pennsylvania, 285 had attended public schools, 19 private schools, and 69 had never gone to school. Of the 2,383 prisoners received into the Eastern Penitentiary of the same

State during the ten years ending with 1869, 17.21 per cent. were illiterate, and 81.83 per cent. had never been apprenticed. "All observers will admit," remarks the author, "that there is not as much intelligence and skill working on the farms now as there was twenty years ago. The fears of the farmers were not that their sons would *know* too much, but that they would do too little. It was not book-farming, or wisdom with work, they feared; but making hay in the shade, or farming by the fireside; plucking geese in the courts, preaching for practice, pills for pumpkins, the pen and yard-stick for the plough and harvest-fork. The change has not been from prison to school so much as from honest labor to idleness and crime. Everything else being equal, mental culture raises the standard of morality; but we would choose a community of industrious and illiterate members, rather than one of idle and literary habits, for a high standard of morality."

**Latest Phase of the Spontaneous-Generation Controversy.**—Dr. Bastian, of London, having submitted to the Paris Academy of Sciences the results of certain experiments which, as he maintains, decisively confirm his theory of spontaneous generation, Pasteur criticised the English investigator's methods and conclusions, and asked for the appointment of a commission to determine on which side the truth lies. At the same time he expressed a wish that Dr. Bastian should in like manner ask the London Royal Society to appoint a similar commission. According to the terms of M. Pasteur's challenge, Dr. Bastian must obtain, in the presence of competent judges, bacteria in sterile urine on the addition of liquor potassæ in suitable quantities, the liquor potassæ being prepared from pure potash with pure water; or, if made from impure materials, it must be submitted to a temperature of 230° for twenty minutes. Dr. Bastian has accepted the challenge, and has applied to the Royal Society for the appointment of the commission. The French commission is already constituted: it consists of Milne-Edwards, Dumas, and Boussingault. The *Lancet* justly complains against this selection, on the ground that all of the three commissioners are more or less strong supporters of Pasteur's view. Their bias must inevitably indispose them toward Bastian's arguments. The *Lancet* asks why Frémy or Trécul, or some other man without bias either way, was not placed on the commission. The Academy has apparently made a mistake in this matter; perhaps when the comments of the *Lancet* are brought to the notice of the members, a change will be made in the commission. The Royal Society has not yet named the members of the English commission.

**Action of the Retinal Nerves.**—Some years ago, while suffering from indisposition, Prof. Tait observed that, whenever he awoke from a feverish sleep, the flame of a lamp, seen through a ground-glass shade, assumed a deep-red color, the effect lasting about a second. He supposes that the nerve fibrils of the retina also slept, and that, on awaking, the green and violet nerves resumed their functions a little later than the red. This observation of Tait's is recalled by Prof. Ogden N. Rood, in the *American Journal of Science*, who adds an analogous observation of his own, going to show that after nervous shock the green nerves (to adopt the theory of Young) receive their activity later than the red, and probably later than the violet nerves. Having taken chloroform at the hands of a dentist, he observed with surprise, on regaining consciousness, that the operator's face was very red, and the next instant that his hair was of a purplish-red hue. The illusion persisted for a second or two. Prof. Rood then gives an instance of chronic effects of similar character which were observed for a couple of weeks continuously, during convalescence from typhoid fever. In this case white objects appeared of a not very intense orange-yellow; here the activity of the green and yellow nerves was diminished relatively to that of the red.

**Food of the Water-Tortoise.**—Though proverbial for its sluggishness, the water-tortoise, according to a writer in *Science Gossip*, appears to have a special relish for the natural food of the cat. Keeping a couple of them in an aquarium, but uncertain as to the kind of food best suited to their needs,

this gentleman fed them at first with worms, slugs, and flies, and of the latter they seemed very fond; yet they did not thrive. One morning on entering the room in which their tank was placed, he discovered a sparrow which had got in through an open window, and which in its efforts to escape had fallen into the tank, when the larger tortoise quickly seized it by the leg and drew its head under the water until it was drowned. Two hours afterward nothing remained of the bird but the wing-feathers, and cleanly-picked bones; all the rest of it having been devoured. After this the animals would not touch even flies for nearly a week; but then, on offering them a dead gold-fish about five inches long, they ate it eagerly, leaving nothing but the head and backbone. A week or ten days later, a live mouse was dropped into the tank, and, like the sparrow, this was soon seized by the larger tortoise—by the head instead of the legs—and pulled under the water until drowned. The head was then torn off, the skin turned inside out and rejected, and all the other parts devoured except the bones. This food appeared to agree with them perfectly, and they were afterward supplied with mice, on which they grew rapidly and kept in excellent condition.

**Fielding Bradford Meek.**—The *American Journal of Science and Arts* for March contains an obituary notice of Fielding Bradford Meek, whose death occurred on December 21st. From it we gather the following particulars relating to the life and labors of that distinguished paleontologist: He was born in Madison, Indiana, on December 10, 1817, and in early manhood chose a mercantile career. Here he was unsuccessful, and in 1848 he became an assistant in the United States Geological Survey of Iowa, Wisconsin, and Minnesota. In 1852 he was assistant to Prof. Hall, at Albany, in the paleontological work of the State of New York. Here he remained until 1858, with the exception of three summers spent on geological surveys of Western States and Territories. In 1858 he went to Washington, and there remained till his death, except while in the field. The invertebrate paleontology of the Rocky Mountain region, as developed by Dr. Hayden's survey, was intrusted to Meek. He also helped to work up the invertebrate paleontology of Illinois, Ohio, California, and sundry Territories surveyed by other expeditions besides Hayden's. Thoroughness, scrupulous exactness, and nice powers of discrimination, are manifested in all his labors. "No one in America," says Dr. C. A. White, the author of the obituary notice from which we quote, "has done more than he to systematize and advance the science to which he devoted his life." His health was always precarious, and for several years before his death he was entirely deaf. He never married, and left no near relatives.

**The Electrical Phenomena of the Torpedo.**—Marey has lately been engaged in studying the electrical discharges of the torpedo, with the aid of a very delicate electrometer and an inscribing apparatus. His experiments show that, on exciting a nerve of the animal's electrical apparatus, a flow of electricity follows in about one-eightieth of a second, lasting about one-fortieth of a second. The voluntary discharge of the torpedo consists of successive flows of currents, varying, according to temperature, from twenty to one hundred and forty shocks per second; the direction of the currents being from the back to the belly. As the currents continue to flow for a longer time than the intervals between the times of their commencement, it happens that several currents flow simultaneously, and thus the intensity of the discharge is increased by accumulation. The phenomena correspond closely to those of muscular work.

**The Appalachian-Mountain Club.**—Prof. E. C. Pickering, President of the Appalachian-Mountain Club, in his annual address, congratulates the club on the large attendance of members at the ten meetings so far held, and the interest manifested in the labors of the club. The principal scientific work of the club for the past season was in the direction of topography—collecting all the available measurements from the works of Bond, Lock, Vose, and Hitchcock. A complete map of the White Mountains has been made by Mr. Henck. One of the greatest achievements of the club is the introduc-

tion of Edmands's Topographical Camera, an instrument by means of which mountain profiles may be drawn with great accuracy. The work done by the president himself includes between 6,000 and 7,000 measurements of the horizontal and vertical positions of the mountains. The "Department of Improvements" has constructed a substantial path which makes the peak of Mount Adams easily accessible to any good pedestrian. An excellent camp has been established on Mount Adams, which will doubtless soon be followed by others. The club at present has its headquarters in the Massachusetts Institute of Technology, but this arrangement is only temporary, and it is the intention of the Council, as soon as possible, to hire a room in which to collect a library of books, maps, photographs, and paintings of the mountains. A summer school of topography, under the auspices of the club, and with special reference to State surveys, is in contemplation.

**Economy in Stock-Feeding.**—We commend to the attention of such of our readers as are farmers a paper by Prof. Samuel W. Johnson, in the *American Journal of Science and Arts* for March, on "The Composition of Maize-Fodder." The paper is extremely valuable, and abounds in practical observations, for two or three of which we make room here. Regarding the influence of age upon the content of albuminoids in forage plants, the author states that quite young meadow-grass as it is found in pasturage contains in its dry matter twenty-four per cent. of albuminoids, cut just before bloom twelve per cent., and at the end of blossoming eight per cent. In case both of maize-fodder and meadow-grass the inferior quality of the older vegetation is compensated by the superior quantity. The author holds that in New England the farmers can raise or buy Indian corn, cotton-seed, meal, and other concentrated foods, and combine them with coarse fodder to make a cattle food equal or superior to the best of hay, at less cost than is involved in feeding the latter. But to throw cured maize-fodder out in the cattle yard, or to feed it in the stall as hay is fed, is highly wasteful. It cannot be fed alone or as an adjunct to hay: to use it profitably it must be finely cut and well mixed or alternated with maize or cotton-seed meal, bran, or some similar material. Maize meal and similar articles contain too much albuminoids, fat, and starch, for healthy and economical cattle food; maize-fodder contains too little of these and too much coarse fibre; the two should be mixed.

**Where the Ancients got their Tin.**—Shortly before his death, Karl Ernst von Baer contributed to the *Archiv für Anthropologie* a paper entitled "Whence came the Tin for Ancient Bronze?" The subject is one that has long engaged the attention of archæologists, but hitherto the only sources assigned for this tin have been Cornwall and the straits of Malacca. There has, however, been a vague notion that tin may also have been derived from Georgia, Armenia, or Persia. To decide this question, Von Baer addressed an inquiry to M. Semenow, Vice-President of the Russian Geographical Society, who obtained the desired information from a traveler named Ogorodinkow. According to his report, tin occurs and has been worked in two localities in Khorassan. It was the opinion of Von Baer that many of the bronzes of Assyria and Babylonia were made from tin obtained in this region.

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## NOTES.

THE *Christian Union* has begun the publication of a series of articles, by distinguished writers, on "How to spend the Summer." Each writer will speak from personal experience, and, if the articles we have seen are a fair sample of those to come, everybody seeking health or pleasure, either at home or abroad, will be profited by reading them.

ADMISSION to hospital for purposes of clinical instruction has at last been granted to female medical students in London. This removes the only remaining obstacle to a complete medical course for women in England; and the concession came just in time to prevent the break-up of their leading medical school.

DURING the coming summer a limited number of teachers of mathematics or astronomy will be permitted to spend a portion of their vacation at the Cincinnati Observatory, in the pursuit of studies connected with their special departments of instruction. Particular attention will be paid to the art of computing, in order to give an

insight into the practical application of mathematics to astronomy. Opportunity will also be afforded to learn the use of instruments.

SIEGFRIED STEIN advocates the employment of rock-crystal for making normal standards of weight and measure, and other instruments of precision. The advantages of rock-crystal for these purposes consist in its indifference, at common temperature, to the action of acids and bases, or of atmospheric gases or moisture.

A NEW method of cleaning the skeletons of small animals, by utilizing the enormous appetites of tadpoles, is described in the *English Mechanic*. M. Lareste, the discoverer, has found that the tadpoles may be quickly habituated to a meat-diet, and that they rapidly denude the bones, when the carcass, previously skinned, is presented to them in water, kept in a warm and somewhat darkened place.

THE syllabus of a course of lectures on American prehistoric archæology, to be delivered before the College of Fine Arts of Syracuse University, during the spring term of 1877, by Dr. Wills De Hass, comprises such topics as "Discovery and Settlement of the Atlantic Coast," "Lost Semi-Civilization of the Mississippi Valley," "Tumular Monuments," "Mural Works," "Art-Remains in Stone," "Rock Sculpture," "Art-Remains in Pottery, also in Bone, Shell, and Metal," "Monumental and Art Remains found in the Lake-Regions," "Origin and Antiquity of the Mound-Builders," etc.

A PREPARATION of tungstate of soda and starch has been highly recommended for rendering muslin dresses uninflammable. At a recent trial of it in London, the dress fortunately being placed on a dummy, the saturated fabric readily took fire, blazed up, and was quickly consumed.

THE *Sanitary Record* laments that they have no cremation-furnace in London, considering it a breach of hospitality that they cannot offer the facilities for fire-burial to their Indian guests who are so unfortunate as to die in England.

A COURSE of lectures on the elementary principles of stock-breeding was delivered during the spring by Prof. William H. Brewer, at the Scientific School of Yale College, which it is to be hoped will before long appear in book-form. The topics discussed in these lectures are: "Heredity," "Atavism," "Close-Breeding," "Crossing," "Relations of Animals to their Surroundings," "Variation," "Relations between Heredity and Variation," "Breeding to Points," "Limitations of Breeding to Points," "Prenatal Influences," "Relative Influence of Sire and Dam," "Crossing for Immediate Special Uses," and "Profitable Adaptation of Breeds to Special Localities and Conditions."

DR. PHILIP P. CARPENTER, brother of the celebrated physiologist, William B. Carpenter, died in Montreal, May 24th. He was born in Bristol, England, in 1819, was educated at the University of Edinburgh, studied theology first, and preached awhile, and then gave himself up to natural history. He devoted himself to the mollusca, and gave a magnificent collection of shells to the British Museum. In 1859 he came to this country, and, selecting Montreal as his place of residence, went on with his scientific work till the failure of an English bank swept away his property, and he then took to teaching and sanitary reform. He gave a large collection of shells to McGill College, and was known as one of the best authorities on the classification of mollusca. He was a clever writer, a forcible speaker, and a man of refined Christian character.

PROF. E. S. MORSE, of Salem, sailed from San Francisco, June 1st, for Japan, whither he goes on a scientific mission of his own. He will spend the summer months in pursuing his favorite studies of natural history amid Japanese resources, and will devote especial attention to the animals of the coast, dredging a good deal, and carrying on the investigation of the Brachiopoda, which has long been his favorite line of inquiry. He will also make the trip subservient to gathering fresh materials for illustrating the "Second Book of Zoölogy," a text-book which he has begun to prepare. Prof. Morse will also, no doubt, gain much curious and interesting information to enrich the lectures which he will return in time to deliver before the lyceums next season.

BROCA assigns to the terms *anthropology*, *ethnology*, and *ethnography*, the following distinctive significations: anthropology is the general study of man or of the entire human species; ethnology is the study of the natural divisions of this group, which are generally known as the races of man; ethnography is the artificial subdivision of races into peoples.

TWENTY years ago, according to Dr. Siemens, it required over five tons of coal to make a ton of iron rails. Now, a ton of steel rails may be produced from the ore with half that quantity of coal.

THE *Pharmacist* quotes the statement from a foreign journal that chemically pure glycerine, when taken in large quantities, exerts a poisonous effect on the system, comparable, within certain limits, to that produced by alcohol.